Appendix I2

Karst Invertebrate Survey

Technical Report

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KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

Interior of a US 281 road cut cave

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Abstract

Field surveys and background research to assess potential endangered karst invertebrate species habitat were conducted in the vicinity of anticipated improvements to US 281 between Loop 1604 and Borgfeld Road in Bexar County, Texas. A total of 116 features were recorded during field surveys. Some of these were non-karstic, others were karstic but not considered potential habitat, some were open caves, and some were excavated to evaluate potential for karst invertebrate habitat. Sixty features were recommended for excavation; 15 excavation requests were not granted by landowners, and the other 45 were excavated. Thirteen caves and karst features, and one spring were biologically surveyed. Two additional springs were recommended for biological surveys but access was not granted. Ten of the features surveyed contained troglobites, and therefore are considered to be karst invertebrate habitat. Two caves are occupied by rare, non-listed species; they are Power Pole Hole and Stafford Cave. No federally-listed karst invertebrate species were encountered during this study, nor were any *Eurycea* salamanders found.

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Introduction

This karst[1] invertebrate technical report has been prepared as a component of a comprehensive document related to potential environmental impacts resulting from proposed improvements to US 281 in northern Bexar County. In addition to this document, a Geologic Assessment of the study area is also being prepared (Zara 2010).

Nine karst invertebrate species in Bexar County were listed as endangered by the US Fish and Wildlife Service (USFWS) on 26 December 2000 (USFWS 2000). Management areas, known as Karst Fauna Regions (KFRs), have been established for these species (Veni 1994). This project area falls within the Stone Oak KFR. Listed species known to occur in this KFR include the Madla Cave meshweaver *Cicurina madla*, the ground beetle *Rhadine exili*s, and the ground beetle *Rhadine infernalis*. Two species of state-threatened *Eurycea* salamanders (*E. neotenes* and *E. tridentifera*) currently under consideration for federal listing as endangered (USFWS 2009) are also known from the US 281 area. *E. tridentifera* is currently listed as threatened by the State of Texas. The US 281 corridor lies within 3 km (1.86 mi) of critical habitat units[2] (CHUs) 12, 13 and 21, designated for *Rhadine exilis* by USFWS.

Five karst zones have been established in the Bexar County area based on their likelihood of containing habitat for listed karst invertebrate species (USFWS 2006, modified from Veni 1992; 1994; 2002). These karst zones are defined as follows:

- Zone 1: Areas known to contain endangered karst invertebrate species
- Zone 2: Areas having a high probability of containing suitable habitat for endangered karst invertebrate species
- Zone 3: Areas that probably do not contain endangered karst invertebrate species
- Zone 4: Areas that require further research but are generally equivalent to Zone 3, although they may include sections that could be classified as Zone 2 or Zone 5 if more information becomes available
- Zone 5: Areas, both cavernous and non-cavernous, that do not contain endangered karst invertebrate species

The study area falls within Karst Zones 1, 2, and 3. Total size of the study area was 551.7 ha (1,390 ac) with 53 % in Karst Zone 1, 34% in Karst Zone 2 and 13% in Karst Zone 3 (Figure 1).

In accordance with USFWS recommendations for projects proposed in potential habitat for listed karst species (USFWS 2006), a survey for caves and karst features[3] was performed in order to detect potential habitat for these species. Surveys were conducted within existing right-of-way (ROW) and on properties within 500 feet of the proposed project alternatives where right-of-entry (ROE) access was granted. Karst features meeting USFWS (2006) guidelines for warranting excavation and/or presence/absence surveys were excavated and surveyed where ROE was granted for that purpose as detailed in Table 1.

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[1] *Karst*: A landscape characterized by the dissolution of limestone bedrock, often resulting in the formation of sinkholes and caves.

[2] *Critical Habitat Unit (CHU):* a geographic area designated by USFWS that is inhabited by a federally listed species. Critical habitat is more specifically defined in section 3(5)(A)(i) of the Endangered Species Act as, "the specific areas within the geographic area occupied by as species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation and management of the species and (II) which may require special management considerations or protection" (USFWS 2003, 17172).

[3] *Karst feature:* A geologic feature formed by the solution of limestone. The term karst feature encompasses caves, sinkholes, fractures, springs and seeps, soil pipes, and solution cavities.

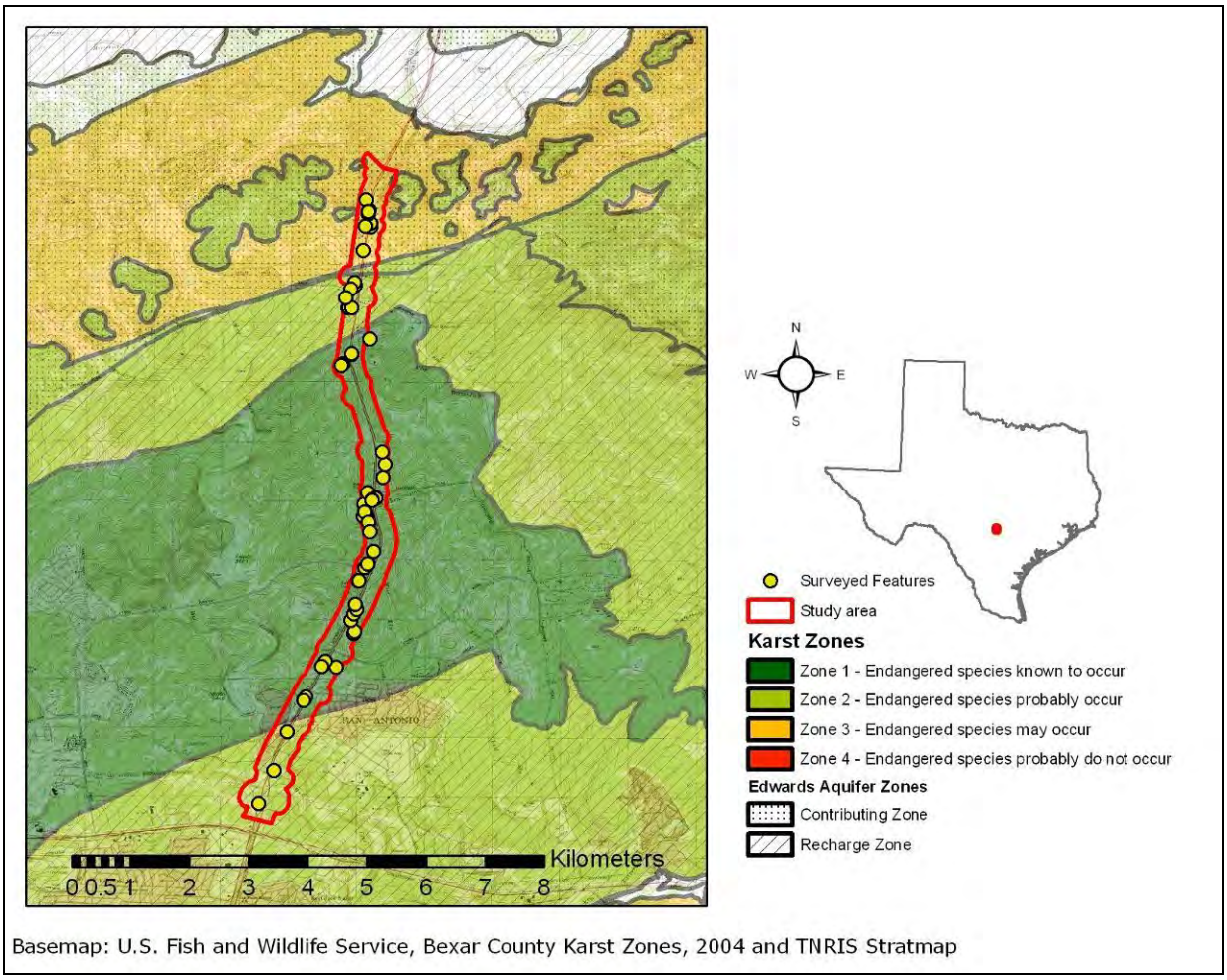

Figure 1. Map of US 281 species study area.

Methods

Background Data Collection

Information on the existing distribution of caves, karst features, and karst species within a 152 m (500 ft) buffer of proposed US 281 improvements was obtained from multiple sources. Records were acquired from the Texas Speleological Survey (TSS). Geospatial data files and documents from the Administrative Record for the 281 Environmental Assessment provided by Texas Department of Environmental Affairs Division (TxDOT ENV) were also obtained. An exhaustive search of Texas Commission on Environmental Quality (TCEQ) files to obtain all accessible previous Geologic Assessments performed in the study area was performed.

Karst Feature Survey

In addition to surveying the current US 281 right-of-way (ROW), an access request ("right of entry," or ROE) was made for all properties within the 152 m (500 ft) buffer. This request was performed by Jacobs Engineering Group. Properties with owners granting permission to enter the premises were surveyed for karst features. Extensive effort was expended on relocating and reassessing features within the ROW and on all properties where ROE was granted.

Karst survey methods followed protocols outlined in the Texas Commission on Environmental Quality (TCEQ) Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones (TCEQ 2004) and USFWS Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence Surveys for Endangered Karst Invertebrates in Central Texas (USFWS 2006). A karst feature survey, as defined by Veni and Reddell (2002), Barrett (1999) and TCEQ (2004), was conducted in the right of way (ROW) and within the 152 m (500 ft) buffer on all properties where access had been granted. The survey area extended from Borgfeld Road in the north to a point just north of Loop 1604 in the south. The southern terminus of the search area adjoined the search area for a companion study being performed on Loop 1604. To perform surveys, two or more surveyors walked in a formation not more than 15 m (50 ft) apart searching for depressions and other indications of potential subterranean habitat. All surveys were supervised by an individual permitted under USFWS Section 10(a)(1)(A) to conduct surveys for endangered karst invertebrates.

All features were documented on an field evaluation form, and positional data were recorded using a hand held Magellan eXplorist model consumer grade Global Positioning System (GPS) receiver, and checked with field maps based on digital ortho-imagery. No differential correction was performed on the GPS data before being transferred to a Geographic Information System.

Excavation and Mapping

Recommendations made by USFWS (2006), paraphrased here, were used to help determine whether features would be excavated in order to determine the potential for endangered species habitat:

If either of the following criterion is met, then excavation is warranted:

A. Feature contains leaf litter or loose, modern soils and rocks.
B. Feature exhibits airflow, channelized recharge, collapse development, loose fill to a depth of greater than 30 cm (1 ft), or clean-washed rocks.

If neither of the above criteria were met, but at least two of the following criteria were met, then excavation is warranted:

C. Feature is developed along a fracture.
D. Feature is more than 2 m (6.6 ft) in length.
E. Feature is more than 1 m (3.3 ft) deep.
F. Feature is similar in appearance to nearby caves in similar geologic setting.
G. A potentially humanly-enterable void is visible.

Table 1 shows whether excavation was warranted for each feature under criteria A and B. In cases where the criteria were not met and additional factors also did not lead to the recommendation of excavation, seven characteristics named by USFWS (2006) and paraphrased here of features not likely to contain suitable endangered species habitat were considered:

H. All or nearly all of the interior surfaces covered with calcite speleothems.
I. Feature floor less than 1.5 m (4.9 ft) below the surface.
J. Absence of troglobites and troglophiles.
K. Features are dry or do not have evidence of modern water flow.
L. Features have fewer than 10 cave crickets.
M. Absence of airflow.
N. Feature not formed by a collapse or related to a collapse.

In addition to these considerations, we evaluated obvious or potential connections to mesocavernous voids[4] in all features. All excavations were performed under the direct supervision of a biologist holding a USFWS 10(a)(1)(A) permit for endangered karst species. Excavations were conducted using hand and power tools. No heavy machinery was used. Features were excavated until one of three conditions was met:

1. a distinct terminus was reached with no mesocavernous voids or drains extending off.
2. suitable habitat (i.e., cave passage) was reached for sampling karst invertebrate species.
3. some type of mesocavernous void continued on from the accessible portion of the feature, but the effort and expense to continue excavation did not justify doing so.

Specifics of the extent and nature of effort expended for each feature are provided in the results section. Except during surveys or excavation, the feature entrance was covered with plywood and black plastic sheeting that was held in place with rocks. The purpose of this covering was to buffer against fluctuations in surface temperature, humidity, and sun exposure. Fauna observations and collections were made as the opportunity arose during excavation activities.

Post-excavation sketches were made for those features that were excavated, and these were used to describe post-excavation dimensions. Features where biological evaluations took place were mapped in accordance with standard cave mapping methods (Dasher 1994). Locations of glue traps and climate stations, as well as original (pre-excavation) floor levels, are shown on these maps. Features over 5 m (16 ft) long were considered to be caves, and were given cave names in most cases. Dimensions of cave and feature entrances at the surface are given, and lengths and depths of caves are shown on cave

[4] *Mesocavernous voids*: also referred to throughout the document as simply "mesocaverns," are small openings that are not humanly enterable. These voids may allow the movement of air, water, and invertebrates through the subsurface.

maps. The length of a cave or karst feature indicates to total traversable extent. The depth refers to the difference in elevation between the lowest and highest parts.

Biological Surveys

Terrestrial karst invertebrate presence/absence survey protocols utilized during this study were developed by USFWS (2006). Surveys were conducted between 14 June and 1 October 2010, within seasons recommended by USFWS (2006), at features determined to have the potential to contain karst invertebrate habitat. Each of (at least) three surveys conducted at each qualifying karst feature were separated by a week-long period of inactivity at the feature. In cases where the site showed evidence of recent flooding, additional surveys were conducted. Between surveys, the features were covered with plywood and black plastic sheeting held down with rocks.

Visual searches for organisms were performed by thoroughly inspecting all exposed surfaces within the void, including the walls, floor, and by examining the insides of cracks and crevices using a headlamp. The undersides of loose rocks were inspected with the naked eye, occasionally aided by the use of a jeweler's loupe for magnification. The floor substrate, including substrate underneath rocks, was also thoroughly examined for organisms.

Tomcat® or similar consumer-type glue traps, which use an adhesive that causes fauna to stick to the trap, were placed in the features and collected on the next visit. Locations of traps are indicated on the feature map. Small amounts of food bait were placed on the traps to attract fauna. Glue traps have been found to be an effective method of supplementing visual searches, since they allow for continual sampling even in the absence of a researcher. A number of organisms recorded during other surveys have been observed or captured on glue traps, including subterranean silverfish (*Texoreddellia*), millipedes (*Cambala*), flies (Diptera), mice (*Peromyscous*), isopods (*Armadillidium, Porcellio, Brackenridgia*), cave crickets (*Ceuthophilus*), ants (Formicidae), cockroaches (Blattaria), springtails (Collembola), true bugs (Hemiptera), beetles (Coleoptera), and spiders (*Cicurina*) (TxDOT 2009).

Any fauna seen in the caves or features, or found in the traps, were noted on field sheets, and in many cases specimens were collected for further identification and to create a museum record of notable fauna from each site. All specimens collected will be deposited at the Texas Memorial Museum at the end of the project. Taxa identified at each feature are included in the feature descriptions located in the Results section of this report.

Identification, ecological classification, and curation of material collected were largely performed by James Reddell of the Texas Memorial Museum. Darrell Ubick (California Academy of Sciences) and James Cokendolpher (Museum of Texas Tech University) assisted with the identification of troglobitic harvestmen and spiders. Subterranean fauna were identified to species level whenever possible, other fauna encountered (i.e. ants, flies) were identified to the ordinal level.

Temperatures used to calculate relative humidity (RH) were measured using a fan-cooled wet and dry bulb psychrometer (Psychro-Dyne®, Industrial Instruments & Supplies, PO Box 416, County Line Industrial Park, Southampton, PA 18966). Atmospheric pressure was measured using a digital barometer built into the Silva Tech$_4$o thermometer. Measurements were taken in the shade at ground level 5 m (16.4 ft) from the cave or feature entrance and inside the feature at multiple stations if the feature was large enough to warrant it. Surface and subsurface RH values were calculated from bulb measurements and atmospheric pressure.

Sampling of springs for *Eurycea* salamanders and stygobitic invertebrates was conducted using four methods, including visual searches, kick-netting, and two different methods of trapping. Visual searches performed in the water around the spring outlets included inspecting the top of the substrate as well as inspecting under rocks and sunken leaves. Kick-netting of the substrate involved forcing sunken debris and aquatic plant matter into nets, and then carefully searching the net contents. Mop heads, which were used successfully in a similar study by Gibson et al. (2008) to detect federally-listed aquifer species, were left at and adjacent to the spring outlets. The mop heads were checked periodically by immersing them in a tub of water and rinsing them out, then searching the rinse water. Bottle traps constructed out of a plastic drink bottle with the neck inverted such that it is easy for a salamander to enter, while making escape difficult,, were baited with bits of food and inserted at or near the spring orifice and checked periodically during the sampling period.

Significant Previously Recorded Features
Known caves and karst features within the 152 m (300 ft) buffer where ROE was not obtained or are now destroyed were reviewed for potential biological significance.

Significant Features Outside of Buffer
In order to help obtain an overview of sensitive karst species habitat in the area adjacent to the study area, a desktop review of known caves and karst features outside of the 152 m (300 ft) buffer was also conducted out to 304 m (1000 ft) from the ROW.

Climate Analysis
The USFWS provides guidelines for recommended season and weather conditions that increase the likelihood of detecting karst invertebrate species (USFWS 2006). These recommendations were taken into consideration for each feature where biological surveys were conducted, and the results of the climate analysis for those features are presented in Appendix H.

Recommended weather condition criteria for sampling include:
1) average weather (temperature and rainfall) for time of year
2) surface air temperatures during the previous week between 4.4° C (40° F) and 37.8° C (100° F)
3) lack of drought conditions
4) recent rainfall
5) absence of recent, extensive, local flooding

The first criterion (average weather for time of year) was evaluated by comparing the 30 year average high and low temperature data to data collected from within the sampling period. The second criterion, which outlines the daily temperature limits for the week preceding each biological survey, was evaluated by recording the high and low temperatures that occurred beginning one week prior to the first survey and continuing through the last survey. The third criterion, lack of drought conditions, was evaluated according to the Palmer hydrologic index and indices of soil moisture, stream flow, precipitation, and vegetation health. The fourth criterion, recent rainfall, was evaluated based on precipitation data obtained from the National Oceanic and Atmospheric Administration (NOAA). The fifth and final criterion, absence of recent extensive local flooding, was evaluated by analyzing local precipitation data and on-site observations.

Results

Background Data
A review of previous reports and literature on karst features in the project area revealed that previous karst feature surveys and inventories had been performed in portions of the study area. Geospatial files and documents from the Administrative Record for the 281 Environmental Assessment provided by TxDOT ENV contained locational information for these features. A significant amount of effort was expended to visit and/or document all of these historic features, which were assigned new feature names corresponding to this project when they were considered to have potential to contain karst invertebrate habitat or were to be recorded for purposes of the Geological Assessment. Previously identified features that had no potential to lead to karst invertebrate habitat, or features located on properties not granting ROE, were not evaluated but are presented as historic features in Appendix A.

Karst Feature Surveys
A pedestrian survey for karst features was conducted from 26 February – 13 May 2010. Access requests were made to landowners within the 152 m (500 ft) buffer of the proposed ROW, and those properties where access was granted were surveyed. Properties where owners granted access for karst feature surveys are identified in Appendix B.

Pedestrian karst feature surveys were completed for the unpaved portions of the US 281 ROW and for all properties allowing access within the 152 m (500 ft) buffer of the proposed ROW between Loop 1604 and Borgfeld Road. A total of 116 features were recorded and sketched (Appendix C) during field surveys, of these 26 were recorded solely for the purposes of developing the Geologic Assessment. Feature locations are provided in Appendix D, and mapped in Appendix E and F.

Excavation and Biological Surveys
Features were recommended for excavation based on the guidelines provided by USFWS (2006), as indicated in Table 1. Site-specific excavation effort details are provided with the description of each site, below.

Presence/absence surveys were conducted at 13 terrestrial sites following USFWS (2006) protocols and at one spring site. The single spring site, 281-003, was sampled for *Eurycea* salamanders six times, but none were found. Ten sites visited during this study contained karst invertebrate habitat, as evidenced by the presence of at least one confirmed troglobitic species. A troglobite sight record at feature 281-085 and a historical troglobite record for Feature 23 Cave where ROE was not obtained bring that total to 12. Most troglobite specimens obtained were of relatively common animals, such as the subterranean silverfish *Texoreddellia* sp. and the millipede *Cambala speobia*. Two rare species, a troglobitic harvestman from features 281-070 and a blind *Cicurina* spider from feature 281-080, were detected. Taxonomic verification for these species was performed by Darrell Ubick and James Cokendolpher (Appendix G).

None of the federally-listed karst invertebrate species or *Eurycea* salamander species were encountered during this study, and none are known to occur within ROW and buffer areas.

Table 1. Summary table of USFWS conditions warranting excavation for features discovered during karst feature. Dashes are entered for sites that were not potential karst features or were already open caves not needing excavation.

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-002									x	x		x	x	x
281-003									x	x		x	x	x
281-004	x								x	x	x	x	x	
281-005	x								x	x	x	x	x	
281-006									x	x	x	x	x	x
281-007									x		x	x	x	x
281-008									x	x	x	x	x	x
281-009	x						x		x	x	x	x	x	
281-010								x	x	x		x	x	x
281-011	x								x	x	x	x	x	
281-012									x	x		x	x	x
281-013	x						x		x	x	x	x	x	x
281-014									x	x	x	x	x	
281-015	x								x		x	x	x	
281-016		x			x				x	x	x	x		x
281-017									x	x		x	x	x
281-018	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-019	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-020	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-021	x								x	x	x	x	x	
281-022	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-023	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-024	x								x	x	x	x	x	
281-025	x		x	x						x	x	x	x	x
281-026	x	x							x	x	x	x	x	
281-027	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-028	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-029	x	x							x	x	x	x	x	

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-030	x								x	x	x	x	x	
281-031	x			x					x	x	x	x	x	
281-032	x	x							x	x	x	x	x	
281-033	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-034	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-035	x			x					x	x	x	x	x	
281-036	x								x	x	x	x	x	
281-037				x		x	x		x	x		x	x	
281-038	x	x							x	x	x	x		
281-039	x	x							x	x	x	x		
281-040	x								x	x	x	x	x	
281-041	x		x						x	x	x	x	x	
281-042	x								x	x	x	x	x	x
281-043	x								x	x	x	x	x	
281-044	x			x	x				x	x	x	x	x	
281-045	x			x			x		x	x	x	x	x	x
281-046	x								x	x		x	x	
281-047	x								x	x	x	x	x	
281-048	x	x		x					x	x	x	x		
281-049	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-050	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-051	x		x						x	x	x	x	x	x
281-052										x	x	x	x	x
281-053	x	x		x					x	x	x	x	x	
281-054									x	x	x	x	x	x
281-055		x	x							x	x	x	x	x
281-056	x								x	x	x	x	x	x
281-057	x								x	x	x	x	x	x
281-058		x		x					x	x	x	x	x	
281-059										x	x	x	x	x
281-060									x	x	x	x	x	x

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-061						x			x	x	x	x	x	x
281-062				x		x	x			x	x	x	x	x
281-063	x						x		x	x	x	x	x	x
281-064	x	x							x	x	x	x	x	
281-065	x	x	x						x	x	x	x		x
281-066									x	x	x	x	x	x
281-067	x	x							x	x	x	x	x	
281-068	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-069									x	x	x	x	x	x
281-070		x				x			x	x	x	x		x
281-071				x	x	x			x	x	x	x	x	x
281-072									x	x	x	x	x	x
281-073		x		x		x			x	x	x	x	x	x
281-074						x			x	x	x	x	x	x
281-075	x	x				x			x	x	x	x		x
281-076									x	x	x	x	x	x
281-077			x						x	x	x	x	x	x
281-078		x				x			x	x	x	x		x
281-079									x	x	x	x	x	x
281-080		x	x		x		x					x		x
281-081									x	x		x	x	x
281-082									x	x	x	x	x	x
281-083	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-084				x			x		x	x	x	x	x	x
281-085				x		x				x	x	x	x	x
281-086				x					x	x	x	x	x	x
281-087								x		x		x	x	x
281-088		x		x		x	x		x	x		x		x
281-089		x		x		x	x		x	x		x		x
281-090					x		x					x	x	x
281-091				x			x		x	x		x	x	x

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-092	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-093	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-094				X					X	X	X	X	X	X
281-095			X		X				X	X		X	X	X
281-096					X					X	X	X	X	X
281-097	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-098			X						X	X	X	X	X	X
281-099	X								X		X			
281-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-101	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-102										X	X	X	X	X
281-103	X	X							X	X	X	X	X	X
281-104			X							X	X	X	X	X
281-105										X	X	X	X	X
281-106	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-107	X									X	X	X	X	
281-108	X								X	X	X	X	X	X
281-109	X								X	X	X	X	X	X
281-111	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-112	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-113	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-114	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-115	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-116	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Conditions: A=Feature contains leaf litter or loose, modern soils and rocks; B=Feature exhibits airflow, channelized recharge, collapse development, loose fill to a depth of >30 cm, or clean-washed rocks; C=Feature is developed along a fracture; D=Feature is more than 2 m (6.5 ft) in length; E=Feature is more than 1 m (3.2 ft) deep; F=Feature is similar in appearance to nearby caves in similar geologic settings; G=A potentially humanly-enterable void is visible; H=All surfaces are covered with calcite speleothems and no black sediment is present; I=Floor occurs less than 1.5 m (4.9 ft) below the surface; J=No troglobites or troglophile species are present; K=Feature is dry (no notable moisture or dampness on surfaces or sediments, no evidence of occasional moisture or speleothem development); L=Fewer than 10 cave crickets; M=Absence of airflow; N=not collapse-formed or related to a collapse

281-001, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-002, spring This is a spring that lies just outside of the eastern US 281 right of way, south of Borgfeld Road. Part of the spring pool is within the ROW, but the apparent spring source is on private land where right of entry was not granted (Figure 2). The spring appears to emerge from sediments, with no obvious single source. The spring pool measured 2 by 7 m (6.6 by 23 ft) when first recorded on 26 February 2010. Surface flow from the spring sank into sediments just downstream of the pool. While any spring in this area is potential habitat for *Eurycea* salamanders, the apparent lack of a bedrock portal for salamanders to retreat into makes that unlikely.

Figure 2. View of the spring pool at feature 281-002.

281-003, spring This spring is located along the eastern US 281 ROW just south of Borgfeld Road. There are five distinct spring sources; four of these emerge from sediment in an area that is 7 m (23 ft) long by 2 m (6.6 ft) wide by 0.3 m (1 ft) deep. The fifth emerges from a weep-hole pipe at the base of a concrete skirt constructed as part of the highway (Figure 3). The source of this water is unknown. The spring pool is bisected by the ROW limit. This site was considered to be potential habitat for *Eurycea* salamanders and was sampled on 13 May, 20 May, 2 June, 11 June, 16 June, and 25 June 2010. No salamanders were found during these surveys.

Figure 3. View of the spring pool at feature 281-003.

281-004, closed depression This is a closed depression that is situated on private property where right of entry was not granted. It is just across a fence line at the base of a persimmon tree (Figure 4). The feature is 0.7 m (2.3 ft) long, 0.5 m (1.6 ft) wide, and 0.25 m (0.8 ft) deep. It may be a solutional sinkhole, or it could be an animal burrow. It was recommended for excavation, but no right of entry was available.

Figure 4. View of feature 281-004 through fence.

281-005, non-karst closed depression/animal burrow This closed depression is mostly in the ROW, but is crossed by a fence and is partially on private property (Figure 5). A hackberry tree is growing out of one side of it. It is 1.5 m (4.9 ft) long, 0.7 m (2.3 ft) wide, and 0.2 m (0.7 ft) deep. Excavation was conducted on 10 September 2010 for 1.5 person-hours and 0.15 m^3 (5.3 ft^3) of material was removed. It was determined to be a burrow made by animals exploiting the roots of the hackberry tree rather than a karst feature

(Figure 6). Post-excavation dimensions of this feature were 1.5 m (4.9 ft) long, 1 m (3.8 ft) wide, and 0.5 m (1.6 ft) deep. A list of fauna encountered in 281-005 can be found in Table 2.

Table 2. Taxa encountered in feature 281-005.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(1 penultimate male, 1 immature)
		Dictynidae	*Cicurina* (eyed)
Isopods	Isopoda	Armadillidiidae*	

*sight identification

Figure 5. Overview of feature 281-005. Chain link fence can be seen crossing the feature.

Figure 6. Feature 281-005 after excavation. It is a burrow made by animals exploiting a root system.

281-006, enlarged fracture This feature is in the road cut on the west side of US 281. The entrance to it is 0.8 m (2.6 ft) wide, 0.4 m (1.3 ft) high, and it extends into the road cut for 1 m (3.3 ft) (Figure 7). It is an enlarged fracture with no infill (Figure 8). Harvestmen (*Leiobunum townsendi*) were observed in this feature. This feature was not recommended for excavation (Table 1).

Figure 7. Overview of feature 281-006.

Figure 8. Interior of feature 281-006.

281-007, solution cavity/enlarged bedding plane This feature is situated in the road cut on the west side of US 281. The entrance to the feature is 0.7 m (2.3 ft) wide, 0.5 m (1.6 ft) high, and it extends into the road cut for 0.5 m (1.6 ft) (Figure 9). It is an enlarged bedding plane with no infill (Figure 10). A list of fauna encountered in 281-007 can be found in Table 3. This feature was not recommended for excavation (Table 1).

Table 3. Taxa encountered in feature 281-007.

Taxa	Order	Family	Species
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Gastropods	Stylommatophora*	undetermined	

*sight identification

Figure 9. Overview of feature 281-007.

Figure 10. Interior of feature 281-007.

281-008, solution cavity/enlarged bedding plane This is an enlarged bedding plane feature in the road cut on the west side of US 281 (Figure 11). The entrance is 0.4 m (1.3 ft) wide, 0.1 m (0.3 ft) high, and it extends into the road cut for at least 1.5 m (4.9 ft) (Figure 12). It is developed in pulverulitic limestone and has no sediment infill. This feature was not recommended for excavation (Table 1).

Figure 11. Overview of feature 281-008.

Figure 12. Interior of feature 281-008.

281-009, closed depressions This is a pair of closed depressions on private property on the west side of US 281 (Figure 13). The feature measures 1.5 by 1 m (4.9 ft by 3.8 ft), and is 0.3 m (1 ft) deep (Figure 14). It may be karstic in origin, or it may have an anthropogenic origin related to a nearby natural gas pipeline. Excavation would be needed to make that determination, and was recommended. ROE for excavation purposes was not granted.

Figure 13. Overview of feature 281-009.

Figure 14. Interior of feature 281-009.

281-010, spring This is a seep spring located on private property on the west side of US 281 (Figure 15). It flows from the travertine-covered base of a 3 m (9.8 ft) tall cliff in an area that is 2 m (6.6 ft) long by 1 m (3.3 ft) wide, but it does not have an identifiable portal (Figure 16). A small amount of water was flowing from it when assessed on 1 March 2010. It is possible habitat for *Eurycea* salamanders, but not likely due to the apparent lack of a portal. It was not sampled for salamanders due to revocation of ROE.

Figure 15. Overview of feature 281-010.

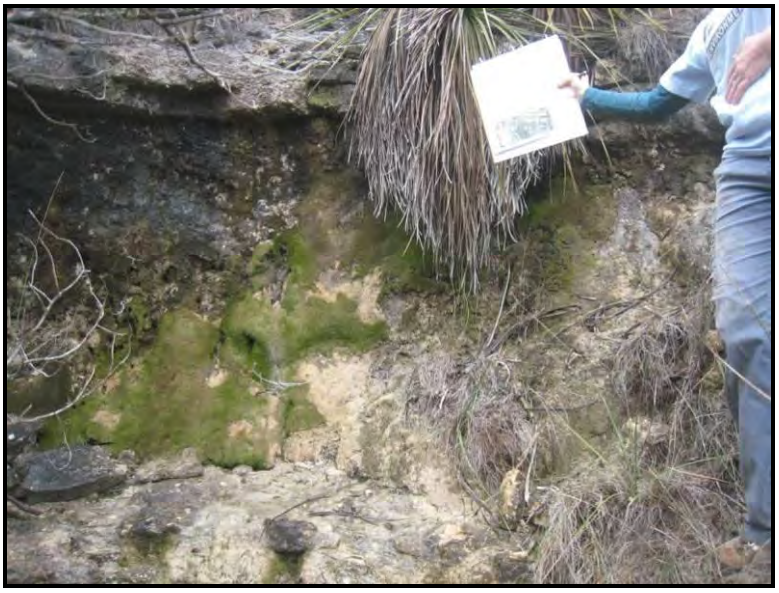

Figure 16. Feature 281-010 exhibits travertine deposition.

281-011, non-karst closed depression This depression is located on private property between a house and some storage units. When first located it was 1.5 m in diameter and 0.7 m deep, and filled with loose rocks (Figure 17) and snakes. Excavation was recommended to determine its origin. This was conducted on 10 August 2010. During this excavation effort, 9.25 person-hours of effort were expended and 1.25 m^3 (44 ft^3) of material was removed. This resulted in a rectangular depression 2.5 m (8.2 ft) long, 1.5 m (4.9 ft) wide, and 1 m (3.3 ft) deep, with a floor of hard-packed soil (Figure 18). Trash was removed from this excavation, and a rusty metal pipe leads into it (Figure 19). This feature appears to be some kind of old septic facility, and is not karst-related. A list of fauna encountered in 281-011 can be found in Table 4.

Table 4. Taxa encountered in feature 281-011.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed, 1 female)
		Dictynidae	*Cicurina* undetermined (eyed)
Millipedes	Julidia	Parajulidae	undetermined
Centipedes	Geophilomorpha	undetermined	
Snakes	Sqaumata	Colubridae	*Thamnophis* sp. *

Figure 17. View of feature 281-011 prior to excavation.

Figure 18. View of feature 281-011 after excavation.

Figure 19. Corroded metal pipe leading into feature 281-011.

281-012, spring This is a spring that emerges from two small bedrock openings in the middle of a creek bed that are 0.2 m (0.7 ft) in diameter. When the site was recorded on 1 March 2010, water was flowing from both the spring orifices and from upstream in the creek (Figure 20). It is not known if the water coming from the spring is merely pirated from the stream flow nearby, or if it has a more distant source. The spring has a well-defined bedrock orifice (Figure 21), which is possible habitat for threatened *Eurycea* salamanders; however it was not sampled due to revocation of ROE.

Figure 20. Overview of spring 281-012. Two spring outlets are present along the bedding plane that cuts diagonally across the picture.

Figure 21. One of two spring outlets at feature 281-012.

281-013, solutional sinkhole This is a karst feature that was initially 0.4 m (1.3 ft) long and 0.3 m (1 ft) wide. It was developed in bedrock, and the bedrock belled out in shape toward the floor 0.15 m (0.5 ft) below the surface (Figure 22). It was filled with fine soils and leaf litter. Excavation was conducted on 11 August 2010 utilizing 9.75 person hours of effort. The feature was enlarged using a jackhammer to a post-excavation size of 0.75 m (2.5 ft) by 1 m (3.3 ft) with a depth of 0.75 m (2.5 ft), where a floor of bedrock and hard-packed clay was encountered (Figure 23). No mesocavernous voids extended from the feature. A list of fauna encountered in 281-013 can be found in Table 5.

Table 5. Taxa encountered in feature 281-013.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed, 2 immature)
Centipedes	Geophilomorpha	undetermined	
Isopods (surface)	Isopoda*	undetermined	
Springtails	Collembola*	Entomobryidae	*Pseudosinella violenta**

*sight identification

Figure 22. Overview of feature 281-013.

Figure 23. Feature 281-013 after excavation, showing solid floor.

281-014, closed depression This is a depression that when initially assessed was 1.5 m (4.9 ft) long, 1 m (3.3 ft) wide, and 0.6 m (2 ft) deep. It was filled with leaf litter and modern soils (Figure 24). The troglophile meshweaver spider *Cicurina varians* was found in this feature. This feature was excavated on 10 August 2010 utilizing 0.8 person-hours of effort, resulting in the removal of 0.1 m^3 (3.5 ft^3) of material. A bedrock floor was reached

at 0.7 m (2.3 ft) depth (Figure 25), with no mesocavernous voids leading off of the feature. The post-excavation dimensions of the feature were 1.5 m (4.9 ft) long, 1 m (3.3 ft) wide, and 0.7 m (2.3 ft) deep.

Figure 24. Overview of feature 281-014 prior to excavation.

Figure 25. Feature 281-014 after excavation, showing bedrock floor.

281-015, collapse sinkhole This depression is located on private property. It is 1.5 m (4.9 ft) long and 0.7 m (2.3 ft) wide, and was covered with trash when initially located on 2 March 2010 (Figure 26). It had soil and leaf litter infill that was loose to a depth of 0.2 m (0.7 ft). The troglophilic meshweaver *Cicurina varians* was found in this feature. Excavation was conducted on 10 August 2010 for one person-hour, resulting in the removal of 0.1 m^3 (3.5 ft^3) of material. A floor of hard-packed clay was reached at 0.25 m (0.8 ft) depth (Figure 27), with no mesocavernous voids extending from the feature. Post-excavation dimensions of the feature were 1.6 m (5.2 ft) long by 0.8 m (2.6 ft) wide by 0.25 m (0.8 ft) deep.

Figure 26. Overview of feature 281-015 prior to excavation.

Figure 27. Feature 281-015 after excavation, showing hard-packed clay floor.

281-016, enlarged fracture This feature is located in the east road cut of US 281 (Figure 28). When initially assessed on 2 March 2010, it had an opening 0.1 m (0.3 ft) in diameter, and it split into two routes with an estimated depth of over 1 m (3.3 ft) (Figure 29). Airflow was detected, suggesting a continuation; therefore excavation of the feature was conducted. On 18 June 2010, 5 person hours of excavation effort was expended utilizing an electric chipping hammer. One cubic meter (35 ft^3) of material was removed. The feature was enlarged to a width of 1.5 m (4.9 ft), with several large slabs still blocking the way. These were removed with a jackhammer on 21 June 2010 in an effort that involved 6 person hours of labor and the removal of an additional 1 m^3 (35 ft^3) of material (Figure 30). Post-excavation dimensions of the feature were 0.7 m (2.3 ft) long by 1.5 m (4.9 ft) wide by 1 m (3.3 ft) deep. Bedrock was reached, with no signs of a drain or karst processes. This feature was likely formed by fracturing caused by excavation of the road cut during

road building activities. Excavation showed that the road cut extended below the current level of bar ditch fill.

Figure 28. Overview of feature 281-016, marked with flagging tape in the lower right side of picture. It was probably fracturing caused during excavation of the road cut.


Figure 29. View of feature 281-016 prior to excavation.

Figure 30. View of feature 281-016 after excavation. Bedrock can be seen on the right, and on the left is fill resulting from grading of the bar ditch.

281-017, solution cavity This feature is situated in the eastern road cut of US 281. It is a solution cavity with two small entrances that are approximately 0.1 m (0.5 ft) in diameter (Figure 31). It drops vertically into the road cut for approximately 0.5 m (1.6 ft). This feature was not recommended for excavation (Table 1).


Figure 31. View of feature 281-017.

281-018, man-made feature This is a water utility site that was recorded for purposes of the Geological Assessment, and is not karst related.

281-019, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-020, man-made feature When initially discovered, this feature was represented by nearly square shaped opening in the ground measuring 0.36 m (1.2 ft) by 0.33 m (1 ft) by

1.75 m (5.7 ft) deep (Figure 32). Photos of the interior of the feature revealed that is an abandoned hand-dug well or cistern (Figure 33). It is not karst related.

Figure 32. Overview of feature 281-020.

Figure 33. Interior of feature 281-020.

281-021, solutional sinkhole This was a solutional sinkhole that measured 0.5 m (1.6 ft) by 0.4 m (1.3 ft) across and was 0.8 m (2.6 ft) deep (Figure 34). It was in-filled with rocks and modern soils (Figure 35). It was recommended for excavation, but ROE for excavation purposes was not granted.

Figure 34. Feature 281-021 prior to brief exploratory excavation.

Figure 35. Feature 281-021 subsequent to removal of loose surface soil.

281-022, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-023, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-024, non-karst closed depression This was a depression measuring 1 m (3.3 ft) long and 0.7 m (2.3 ft) wide and 0.3 m (1 ft) deep (Figure 36). It was filled with leaf litter, modern soils, and trash. Two large rocks were removed from it during excavation on 13 August 2010. Post-excavation dimensions of this feature were unchanged. It was determined that his feature was formed by roots lifting rocks, and it is not karstic.

Figure 36. Overview of feature 281-024.

281-025, Taco Truck Tunnel, cave This is a cluster of closely spaced karst features, one of which is a cave. This cave is in a depression that measures 3 by 4 m (9.8 by 13.1 ft) across (Figure 37). One meter (3.3 ft) to the east of the cave is a solution hole that is 0.4 m (1.3 ft) in diameter. Three meters (10 ft) southeast of the cave is a solutionally-enlarged fracture that measures 0.76 by 0.91 m (2.3 by 2.5 ft), with a bearing of 137 degrees. Four meters (13 ft) to the southeast is a pair of fractures that form a cross 0.78 m (31 in) in diameter. These fractures have bearings of 77 and 167 degrees. The cave feature was recommended for excavation. Excavation took place on 13, 17, 19, 26, 27 August and 15-16 September 2010. Total excavation effort expended was 113 person hours, and 9.5 m^3 (335 ft^3) of soil and rocks was removed. The entrance to this cave is surrounded by sloping bedrock (Figure 38) measuring 1.8 by 1.2 m (5.9 by 3.9 ft) across. It drops 1.3 m (4.3 ft) to a ledge, followed by a 2.3 m (7.5 ft) climb-down to a dirt floor (Figure 39). A crawlway extends to the northwest for 1.5 m (4.9 ft), where the cave ends in a small dome (Figure 40). The post-excavation dimensions of the cave were 5 m (16.4 ft) long by 3.5 (11.5 ft) wide by 5 m (16.5 ft) deep. A lithic arrow point was found during soil excavations at this cave. The cave was named for a nearby dining establishment. Biological surveys on this feature were conducted on 17 and 24 September and 1 October 2010. A list of fauna encountered in 281-025 can be found in Table 6 and microclimate measurements are included in Table 7.

Table 6. Taxa encountered in feature 281-025.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus cunicularis*
			Ceuthophilus secretus (adult, subadults)*
			Ceuthophilus sp. (nymph)*
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Millipedes	Spirostreptida	Cambalidae	*Cambala speobia* (**T**)
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Spiders	Araneae	Dictynidae	*Cicurina* sp.((immature)
Springtails	Collembola*	undetermined	

Taxa	Order	Family	Species
Snakes	Squamata	Colubridae	*Thamnophis* sp.*
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
Snails	Stylommatophora	Helicodiscidae	*Helicodiscus* sp.
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Cockroaches	Blattaria*	undetermined	
Mosquitoes	Diptera*	undetermined	
Moths	Lepidoptera*	undetermined	

*sight identification

Table 7. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-025.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
17 Sept	1618	Surface	25.7	33.0	969	56
17 Sept	-	In cave	26.4	27.7	969	90.3
24 Sept	0855	Surface	24.2	24.7	975	96
24 Sept	0910	In cave	24.5	25.5	975	92.2
1 Oct	0915	Surface	18	22	979	68
1 Oct	0910	In cave	19.5	21.0	979	87.2

Figure 37. Feature 281-025 prior to excavation.

Figure 38. Entrance to feature 281-025 after excavation.

Figure 39. Bottom of feature 281-025 after excavation.

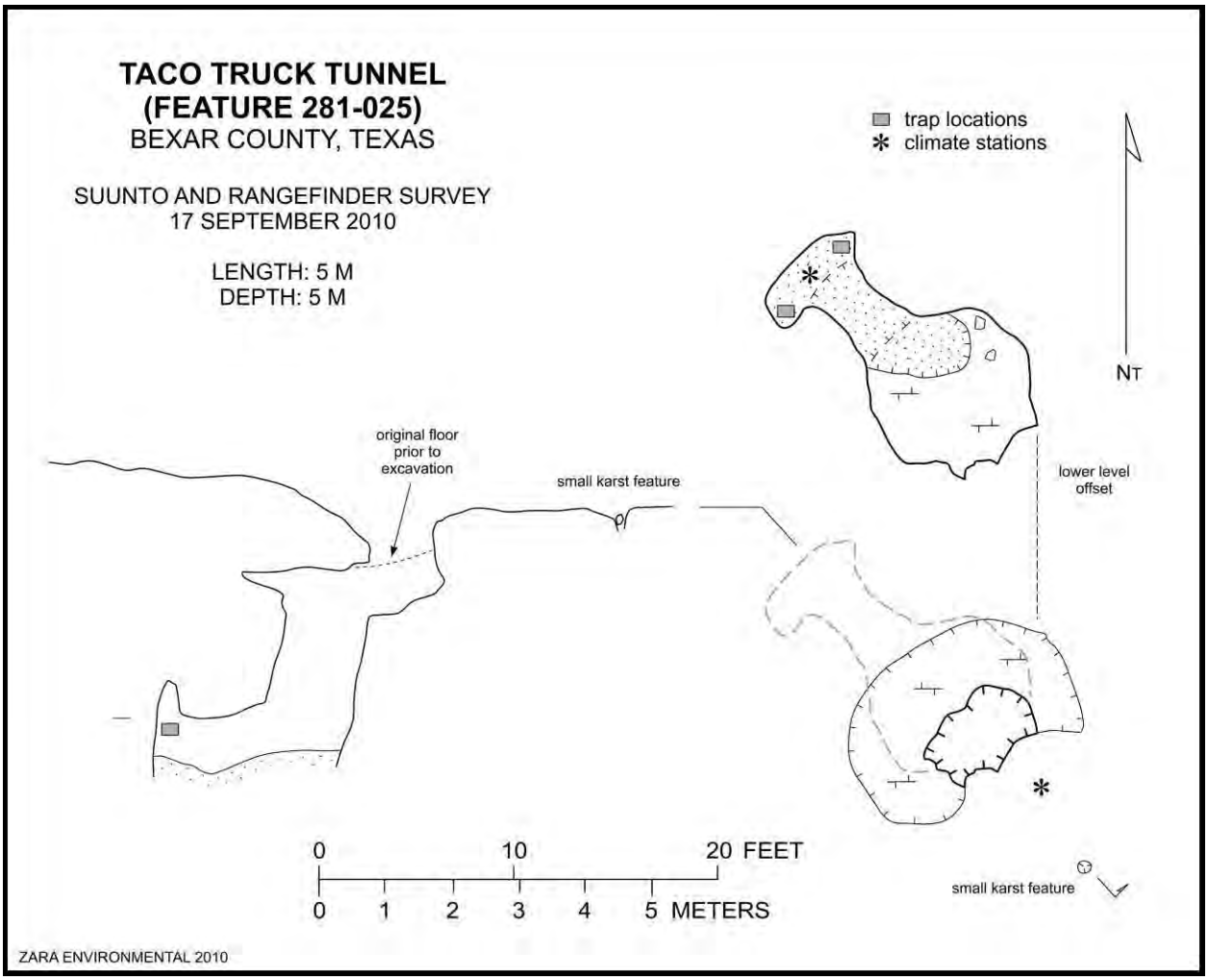

Figure 40. Map of feature 281-025.

281-026, solutional sinkhole This is a solutional sinkhole that was initially 1.3 m (4.3 ft) long and 1.2 m (3.9 ft) wide. It was 0.6 m (2 ft) deep and contained leaf litter and clean-washed rocks (Figure 41). The feature is formed along a fracture trending at 45 degrees. Excavation was conducted with hand tools on 19 August and with a jackhammer on 10 September 2010. A total of 5 person hours of effort was expended, resulting in the removal of 1.3 m^3 (46 ft^3) of material. A bedrock floor was reached at a depth of 0.5 m (1.6 ft) (Figure 42). Lateral excavation along a bedding plane for 0.5 m (1.6 ft) revealed nothing but hard-packed clay (Figure 43). Post-excavation dimensions of the feature were 1.3 m (4.3 ft) long and 1.25 m (4.1 ft) wide and 0.6 m (2 ft) deep. A list of fauna encountered in 281-026 can be found in Table 8.

Table 8. Taxa encountered in feature 281-026.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed, 1 female)
		Dictynidae	*Cicurina* undetermined (eyed: probably *varians*)
Millipedes	Julidia	Parajulidae	undetermined
Centipedes	Geophilomorpha	undetermined	

Figure 41. Overview of feature 281-026.


Figure 42. Overview of feature 281-026 after excavation.

Figure 43. Interior of feature 281-026 after excavation.

281-027, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-028, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-029, solutional sinkhole This is a depression that was initially 0.56 m (1.8 ft) long and 0.48 m (1.6 ft) wide (Figure 43). It had a noticeable drain, and contained fine infill comprised of leaf litter and black, modern soil (Figure 44). Excavation was conducted on 2 August 2010 resulted in the removal of a large rock and decaying sticks. A bottom of hard red clay was reached and no continuing drain could be seen. However, flood debris seen piled on top of the feature after a heavy rain indicates that it may have a high rate of infiltration. Post-excavation dimensions of this feature were 1 m (3.3 ft) in diameter with a depth of 0.3 m (1 ft).


Figure 44. Overview of feature 281-029.

Figure 45. Close-up view of feature 281-029.

281-030, sinkhole This is a depression of undetermined origin that contains old stumps, concrete, and rocks (Figure 46). It measures 0.5 by 0.25 m (1.6 by 0.8 ft), and is 0.2 m (0.7 ft) deep. Excavation was conducted on 2 August 2010, and 1 m^3 (35 ft^3)of material was removed utilizing hand tools. This material consisted of chunks of concrete and juniper stumps (Figure 47). The feature was excavated to a depth of 0.75 m (2.5 ft), about 0.2 m (0.7 ft) past the black soil layer into red and white clay. No drains were found. Post-excavation dimensions of this feature were 1.25 m (4.1 ft) in diameter and 0.75 m (2.5 ft) deep. Due to previous anthropogenic activity at this site, its origin is unclear.

Figure 46. Overview of feature 281-030 prior to excavation.

Figure 47. Feature 281-030 after excavation.

281-031, collapse sinkhole This pair of depressions within an area 3.5 m (11.5 ft) in length by 1 m (3.3 ft) wide (Figure 48 and Figure 49). They had coarse infill of modern soil and may be the result of tree removal. Excavation took place on 2 August 2010, and resulted in the removal of 0.4 m^3 (14 ft^3) of soil from the two depressions (Figure 50 and Figure 51). They were dug to depths of 0.3 and 0.4 m (1 and 1.3 ft) to hard packed bottoms with no drains. Post-excavation dimensions of the features were 1 m (3.3 ft) by 0.5 m (1.6 ft) by 0.4 m (1.3 ft) and 0.5 m (1.6 ft) in diameter by 0.3 m (1 ft) deep.

Figure 48. South depression at feature 281-031 prior to excavation.

Figure 49. North depression at feature 281-031 prior to excavation.

Figure 50. South depression at feature 281-031 after excavation.

Figure 51. North depression at feature 281-031 after excavation.

281-032, sinkhole This is a solutional or collapse sinkhole that is 1 m (3.3 ft) long and 0.8 m (2.6 m) wide (Figure 52). It receives recharge from an area measuring 3 by 5 m (9.8 by 16.4 ft). It contained infill of leaf litter and clean-washed rocks. An opossum was observed in this feature. Excavation was conducted on 2 August 2010. Black soil and rocks were removed from the floor, reaching a hard-packed bottom with no drains at a depth of 0.9 m (2.9 ft) (Figure 53). Post-excavation dimensions of the feature were 1 m (3.3 ft) in diameter and 0.9 m (2.9 ft) deep.

Figure 52. Feature 281-032 prior to excavation.

Figure 53. Feature 281-032 after excavation.

281-033, water well This feature is a well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-034, water well This feature is a well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-035, non-karst closed depressions This is a cluster of three depressions on private property at the northwest corner of Overlook Parkway and US 281 (Figure 54). When initially assessed, their origin was not clear. Excavation took place on 19 August 2010 for 1 person-hour, resulting in the removal of 0.25 m^3 (8.8 ft^3) of material. Excavation reached hard-packed soil at a depth of 0.35 m (1.1 ft). This feature is likely the result of tree-

clearing, not karst processes (Figure 55). Post-excavation dimensions of the largest feature were 1.5 m (4.9 ft) in diameter and 0.35 m (1.1 ft) deep.

Figure 54. Feature 281-035 prior to excavation.

Figure 55. Feature 281-035 after excavation, showing hard-packed dirt floor.

281-036, non-karst closed depression This is a depression located on private property at the northwest corner of Overlook Parkway and US 281. When initially examined, it had a diameter of 1.2 m (3.9 ft) and a depth of 0.5 m (1.6 ft) (Figure 56). It was recommended for excavation, which took place on 19 August 2010. This excavation utilized 1.4 person-hours of effort, and resulted in the removal of 0.1 m^3 of material. A bedrock floor was reached with no mesocavernous voids extending from the feature (Figure 57). Post-excavation dimensions of the feature were 1.5 m (4.9 ft) in diameter and 0.75 m (2.5 ft) deep. This feature is likely the result of tree-clearing, not karst processes.

Figure 56. Feature 281-036 prior to excavation.

Figure 57. Feature 281-036 after excavation, showing bedrock floor.

281-037, Painful Crawl, cave This is an enlarged bedding plane cave in a road cut associated with a parking lot outside of the ROW. It was partially filled with concrete, but a low passage could be seen extending into the road cut (Figure 58). Excavation was conducted on 15-16 September 2010. This resulted in 2 m^3 (106 ft^3) of rocks being removed from the cave using 20 person hours of effort with hand and power tools. This cave is developed in a low, wide bedding plane, and is just tall enough for human entry (Figure 59). The bedrock and flowstone floor is rough, giving rise to the name Painful Crawl (Figure 60). Excavation concentrated on removing bits of rock from the floor and ceiling in order to be able to enter the passage, but did not change the existing footprint of the cave. Excavation continued 10 m (32.8 ft) until dark zone habitat was reached. The entrance to Painful Crawl is at the bottom of a sloping road cut that is 3.5 m tall. It is 1.4 m (4.6 ft) wide and 0.4 m (1.3 ft) tall. After 3 m (9.8 ft), the passage takes a turn to the east, with small bedding plane openings also extending off to the south and west at this turn. After

another 4 m (13 ft), a junction is reached. A dig lead to the north appears that it would connect back to the road cut if excavated. A dig lead also extends to the east. The main passage continues to the south for 3 m (9.8 ft) before it gets too low for human entry (Figure 61). Post-excavation dimensions of the cave were 10 m (32.8 ft) long by 5 m (16.4 ft) wide by 0.7 m (2.3 ft) deep. Biological surveys on this feature were conducted on 17 and 24 September and 1 October 2010. A list of fauna encountered in 281-037 can be found in Table 9 and microclimate measurements are included in Table 10.

Table 9. Taxa encountered in feature 281-037.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymph)*
Field Crickets	Orthoptera	Gryllidae*	
Harvestmen	Opiliones*	undetermined	
	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Spiders	Araneae	undetermined	
		Dictynidae	*Cicurina* (eyed: probably *varians*)*
			Cicurina undetermined
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Springtails	Collembola*	undetermined	
Earwig-like Diplurans	Diplura	Campodeidae	
Assassin Bugs	Hemiptera	Reduviidae	
Isopods	Isopoda	Porcellionidae	*Porcellio* sp.
Lampreys	Petromyzoniformes*	undetermined	
Frogs	Anura	Leptodactylidae*	
Gastropods	Stylommatophora	Helicodiscidae	*Helicodiscus* sp.*
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Cockroaches	Blattaria*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 10. Dates of biological surveys and in-cave temperature and humidity measurements at Feature 281-037.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
17 Sept	1340	Surface	27.0	31.5	972	70.6
17 Sept	1350	In cave	27.0	29.0	972	85.7
24 Sept	1200	Surface	25.4	28.3	977	79.3
24 Sept	1218	In cave	26.5	28.0	977	88.9
1 Oct	1033	Surface	23.7	24.5	974	93.6
1 Oct	1040	In cave	23.5	23.8	974	97.5

Figure 58. Feature 281-037, which was partially filled with concrete.

Figure 59. Entrance to feature 281-037 after enlargement by excavation.

Figure 60. Interior of feature 281-037.

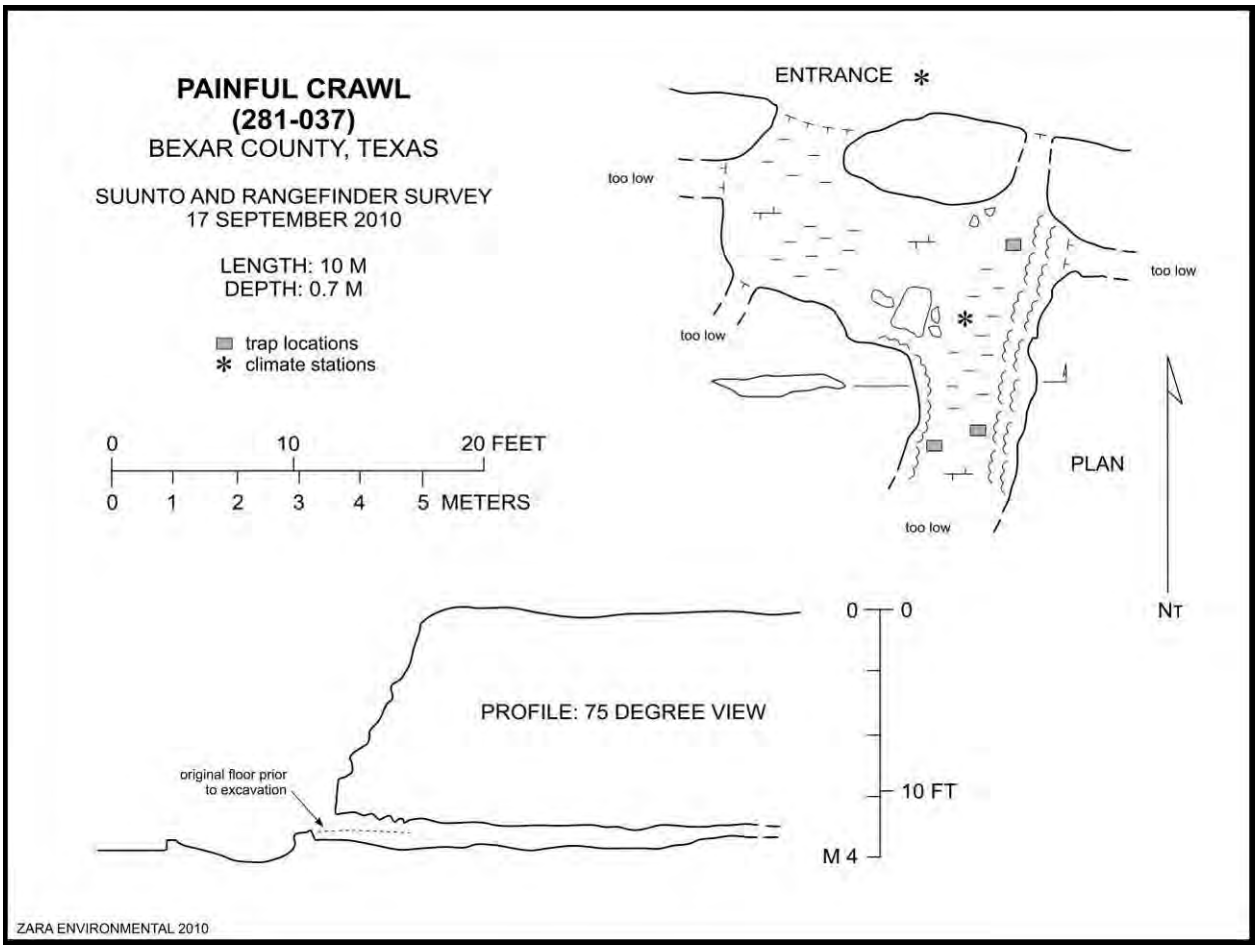

Figure 61. Map of feature 281-037.

281-038, solutional sinkhole This is a solutional sinkhole that is 2.3 m (7.5 ft) long, 1 m (3.3 ft) wide, and 0.4 m (1.3 ft) deep. It consists of two holes draining under a bedrock shelf with infill of leaf litter and modern soil that is loose to a depth of 0.2 m (0.7 ft) (Figure 62). Excavation was recommended, but ROE for excavation purposes was not granted.

Figure 62. Overview of feature 281-038.

281-039, non-karst closed depression This feature is located on private property on the west side of US 281. When initially located it was a depression 0.25 m (0.8 ft) in diameter and 0.13 m (0.4 ft) deep, with a coarse infill of rocks and modern soils (Figure 63). Excavation was conducted on 10 September 2010. This utilized 0.6 person-hours of effort and removed 0.1 m^3 (3.5 ft^3) of material. Post-excavation dimensions of this feature were 1.5 m (4.9 ft) long by 0.75 m (2.5 ft) wide by 0.5 m (1.6 ft) deep. This feature is located in a landfill deposit, and is a result of poor consolidation (Figure 64). It is not a karst feature.

Figure 63. Feature 281-039 prior to excavation.

Figure 64. Feature 281-039 after excavation, showing landfill rocks.

281-040, non-karst closed depression This feature is located on private property on the west side of US 281. When initially located, it was 1.3 m (4.3 ft) in diameter and 0.3 m (1 ft) deep (Figure 65). It had infill of leaf litter and black, modern soil. Excavation was conducted on 10 September 2010, utilizing 1 person-hour of effort and removing 0.2 m^3 (7 ft^3) of rocks and soil to a bedrock floor (Figure 66). Post-excavation dimensions of this feature were 1.4 m (4.6 ft) in diameter and 0.6 m (2 ft) deep. This feature is erosional in origin, likely the result of bedding plane slumping on a hillside slope.

Figure 65. Feature 281-040 prior to excavation.

Figure 66. Feature 281-040 after excavation.

281-041, enlarged fracture This solutionally-enlarged fracture is located on private property on the west side of US 281. Prior to excavation, it measured 0.8 m (2.6 ft) in length by 0.1 m (0.3 ft) in width, and was 0.3 m deep (Figure 67). It contained fine, black sediment of modern origin. Excavation was conducted with a jackhammer on 10 September 2010 utilizing 2 person-hours of effort and removing 0.3 m^3 (10.6 ft^3) of material. The excavation reached a bedrock floor at a depth of 0.6 m (2 ft), with no mesocavernous voids extending off of it (Figure 68). Post-excavation dimensions of the feature were 1.25 m (4.1 ft) long by 0.75 m (2.5 ft) wide by 0.6 m (2 ft) deep.

Figure 67. Feature 281-041 prior to excavation.

Figure 68. Bedrock floor of feature 281-041 after excavation.

281-042, non-karst closed depression/animal burrow This feature is located on private property on the west side of US 281. When initially assessed, it consisted of two depressions within an area measuring 1 by 2 m (3.3 by 6.6 ft) (Figure 69). It had infill of leaf litter and modern soil that was loose to a depth of 15 cm (0.5 ft). Excavation was conducted on 10 September 2010. This effort utilized 1 person-hour of effort and removed 0.1 m^3 (3.5 ft^3) of material. Post-excavation dimensions of the largest feature were 0.75 m (2.5 ft) in diameter and 0.3 m (1 ft) deep. This feature is an old, filled animal burrow that goes under a slab of limestone and exits the other side (Figure 70). It is not a karst feature.

Figure 69. Feature 281-042 prior to excavation.

Figure 70. Feature 281-042 after excavation.

281-043, non-karst closed depression/animal burrow This depression was 2 m (6.6 ft) in diameter and 1 m (3.3 ft) deep when initially assessed (Figure 71). It had fine infill of leaf litter and black, modern soil. Excavation was conducted on 3 August 2010; 1 m^3 (35 ft^3) of dirt and leaves was removed from the feature. Post-excavation dimensions of the feature were 2 m (6.6 ft) long by 2.5 m (8.2 ft) wide by 1 m (3.3 ft) deep. The floor was hard-packed red clay, with an animal burrow at the south end of the feature (Figure 72). Construction activities on this ROE site later resulted in the area being graded over.

Figure 71. Feature 281-043 prior to excavation.

Figure 72. Feature 281-043 after excavation.

281-044, solutional sinkhole When initially assessed, this solutional sinkhole was 2.5 m (8.2 ft) long, 1.25 m (4.1 ft) wide, and 1.2 m (3.9 ft) deep (Figure 73). It contained infill composed of leaf litter and modern, black soil that was loose to a depth of 20 cm. It is recharged by sheet-wash from an area measuring 30 by 30 m (98 by 98 ft). Excavation on 3 August 2010 removed 2.5 m^3 (88 ft^3) of loose soil and rocks, deepening the feature to 1.8 m (5.9 ft) (Figure 74). Post-excavation dimensions of this feature were 2.5 m (8.2 ft) long, 1.25 m (4.1 ft) wide, and 1.8 m (5.9 ft) deep. At that point ROE for excavation was revoked, preventing further excavation that would likely have led to a cave. The feature was backfilled.

Figure 73. Feature 281-044 prior to excavation.

Figure 74. Feature 281-044 during excavation.

281-045, cave This feature is located in drainage, and consists of two low, enlarged bedding planes that cut back under the drainage (Figure 75 and Figure 77). Flood waters cascading down over the top of these entrances has caused scour, piling up gravel and rocks just downstream. The westernmost of the two entrances extends in for 3 m (9.8 ft) to a bedrock terminus (Figure 76). The eastern entrance extends 4 m (13.1 ft) and also terminates in bedrock (Figure 78). Excavation was conducted on 4, 19, and 25 August to enlarge these bedding plane openings for biological evaluation. Using hand and power tools, 2 m^3 (71 ft^3) of material was removed with 25.5 person hours of effort. The cave was mapped during a subsequent visit (Figure 79).Post-excavation dimensions of this feature were 7 m (23 ft) long, 4 m (13.1 ft) wide and 0.7 m (2.3 ft) deep.

Biological surveys on this feature were conducted on 1, 12, and 24 September 2010. A complete list of fauna encountered in 281-045 can be found in Table 11 and microclimate measurements are included in Table 12.

Table 11. Taxa encountered in feature 281-045.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus secretus* (juvenile)*
Field Crickets	Orthoptera	Gryllidae (nymphs)*	
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Spiders	Araneae*	undetermined	
		Dictynidae	*Cicurina* sp. (immature)
Springtails	Collembola*	undetermined	
Ground Beetles	Coleoptera	Carabidae	
Assassin Bugs	Hemiptera	Reduviidae*	
Isopods	Isopoda	Porcellionidae	*Porcellio* sp.*
		Oniscoidea	(1 eyed – could not be keyed due to size)
		Armadillidiidae	*Armadillidium vulgare**
Centipedes	Scolopendromorpha*	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Gnats and Mosquitoes	Diptera*	undetermined	
Mice	Rodentia*	undetermined	

*sight identification

Table 12. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-045.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
1 Sept	-	-	-	-	-	-
9 Sept	1346	Surface	25.8	31.2	970	65.2
9 Sept	1349	In cave	25.5	27.5	970	85.3
12 Sept	1221	Surface	27	33.5	978	60.5
12 Sept	1230	In cave	28.0	31.0	978	79.7
24 Sept	0942	Surface	24.8	26.5	975	87.1
24 Sept	0958	In cave	25.7	26.3	975	95.3
24 Sept	1000	In cave	26.0	26.5	975	96.1

Figure 75. Entrance to the western portion of feature 281-045.

Figure 76. Terminus of the western portion of feature 281-045 after excavation.

Figure 77. Entrance to the eastern portion of feature 281-045.

Figure 78. Terminus of the eastern portion of feature 281-045 after excavation.

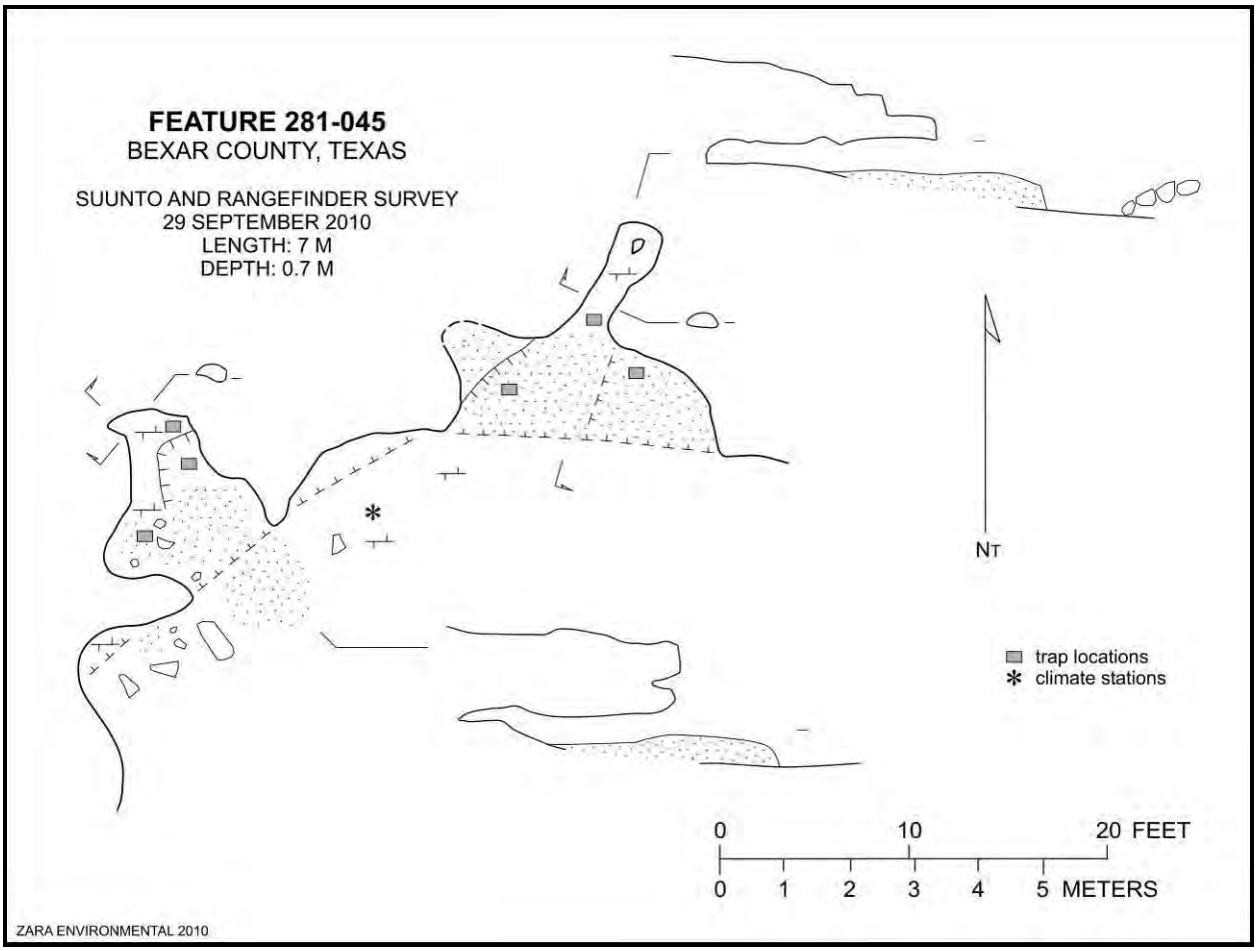

Figure 79. Map of feature 281-045.

281-046, non-karst closed depression/animal burrow When initially assessed, this feature was a depression 0.3 m (1 ft) in diameter containing roots and water (Figure 80). It had infill of leaf litter and modern, black soil. Excavation conducted on 4 August 2010 removed some soil, and revealed an animal burrow. Post-excavation dimensions of the feature were 1 m (3.3 ft) in diameter by 0.5 m (1.6 ft) deep (Figure 81). It is not a karst feature.

Figure 80. Feature 281-046 prior to excavation.

Figure 81. Feature 281-046 after excavation.

281-047, solutional sinkhole When initially assessed, this feature was 1.5 m (4.9 ft) long, 1 m (3.3 ft) wide, and 0.4 m (1.3 ft) deep (Figure 82). It contained fine black sediment of modern soil and leaf litter. It was excavated on 3 August 2010 to a solid bedrock floor (Figure 83).

Figure 82. Feature 281-047 prior to excavation.

Figure 83. Feature 281-047 after excavation.

281-048, solutional sinkhole This solutional sinkhole was 3 m (9.8 ft) long and 1 m (3.3 ft) wide and 2 m (6.6 ft) deep (Figure 84) and contained fine infill of black, modern soil and

leaf litter (Figure 85). Airflow was detected in the feature on 12 March 2010. It was recommended for excavation, but ROE for excavation purposes was denied.

Figure 84. Overview of feature 281-048.

Figure 85. Interior of feature 281-048.

281-049, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-050, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not considered a karst feature.

281-051, enlarged fractures This is a set of enlarged cross-fractures located on private property. The feature was 2.5 m (8.2 ft) long, 0.2 m (0.7 ft) wide, and 0.3 m (1 ft) deep. The main fracture trends at approximately 90 degrees, with several minor fractures crossing at 45 degrees (Figure 86). It receives sheet-wash drainage from an area measuring 20 by

30 m (66 by 98 ft). It has infill of black, modern soil and leaf litter that is loose to a depth of 0.3 m (1 ft). It was recommended for excavation, but ROE for excavation purposes was not obtained.

Figure 86. Overview of feature 281-051.

281-052, non-karst closed depression This feature is located on the west side of US 281 on private property. It is a 10 m-diameter (32.8 ft) depression with a depth of 1.5 m (4.9 ft) (Figure 87) formed by the introduction of landfill material on its north side and not by karst processes. This feature was not recommended for excavation (Table 1).

Figure 87. Overview of feature 281-052.

281-053, non-karst closed depression It is located on the west side of US 281 on private property. It is composed of three openings within an area that is 3 m (9.8 ft) long, 0.6 m (2 ft) wide, and 1 m (3.3 ft) deep (Figure 88). This feature is located in the same landfill deposit as feature 281-052. It was recommended for excavation, but when excavation commenced on 10 September 2010, it was immediately determined to be non-karstic. It is formed in a landfill deposit, and is a result of collapse or piping into loose fill.

Figure 88. Overview of feature 281-053.

281-054, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane at the base of a road cut on private property on the east side of US 281 (Figure 89). This opening is 8 m (26.2 ft) wide, 0.3 m (1 ft) tall, and extends at least 0.6 m (2 ft) into the cut (Figure 90).

Figure 89. Overview of feature 281-054.

Figure 90. Interior of feature 281-054.

281-055, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane at the base of a construction site road cut on private property. It is 2 m (6.6 ft) wide, 1.7 m (5.6 ft) tall, and extends into the road cut for 1 m (3.3 ft) (Figure 91). It is developed along a fracture bearing 90 degrees. It was recommended for excavation, but ROE for excavation purposes was not granted.

Figure 91. Overview of feature 281-055.

281-056, non-karst closed depression/animal burrow This feature is located on the east side of 281, in the north flood plain of Mud Creek. When initially assessed, it was a depression in soil 1 m (3.3 ft) in diameter and 0.5 m (1.6 ft) deep (Figure 92). Excavation was conducted at this feature on 20 May 2010 by two persons for 50 minutes. Approximately 0.05 m^3 (1.8 ft^3) of fill was removed from the feature to reveal an animal burrow (Figure 93). Post-excavation dimensions of this feature were 1 m (3.3 ft) in diameter by 0.75 m (2.5 ft) deep. The only fauna encountered in this feature were a surface centipede in the order Scutigeromorpha (family Scutigeridae) and a rattlesnake (*Crotalus atrox*).

Figure 92. Feature 281-056 prior to excavation.

Figure 93. Feature 281-056 after excavation. It is an animal burrow.

281-057, solutional sinkhole This feature consisted of a depression that was 1.5 m (4.9 ft) in diameter and 0.4 m (1.3 ft) deep (Figure 94). It had a large rock on its south side, and was filled with fine black sediment and leaf litter that was loose to a depth of 0.3 m (1 ft). There was a small tree with some exposed growing from the feature. The feature receives sheet wash flow from an area measuring 25 by 30 m (82 by 98 ft). It was recommended for excavation; however ROE was rescinded prior to the initiation of excavation activities.

Figure 94. Overview of feature 281-057.

281-058, sinkhole This is potentially a collapse or solutional sinkhole that is 3.5 m (11.5 ft) in diameter and 0.7 m (2.3 ft) deep. It is filled with soil and has two live oak trees growing out of it (Figure 95). It was recommended for excavation in order to determine its origin; however, ROE was rescinded prior to the initiation of excavation activities.

Figure 95. Overview of feature 281-058.

281-059, non-karst closed depression This depression is 5 m (16.4 ft) long, 3 m (9.8 ft) wide and 0.5 m (1.6 ft), and is surrounded by a curbed parking lot. There are two oak trees within it (Figure 96). It was most likely formed by the area surrounding it being built up for the parking lot, with the area around the trees left unfilled so that the trees would not die. It is a non-karst closed depression. This feature was not recommended for excavation (Table 1).

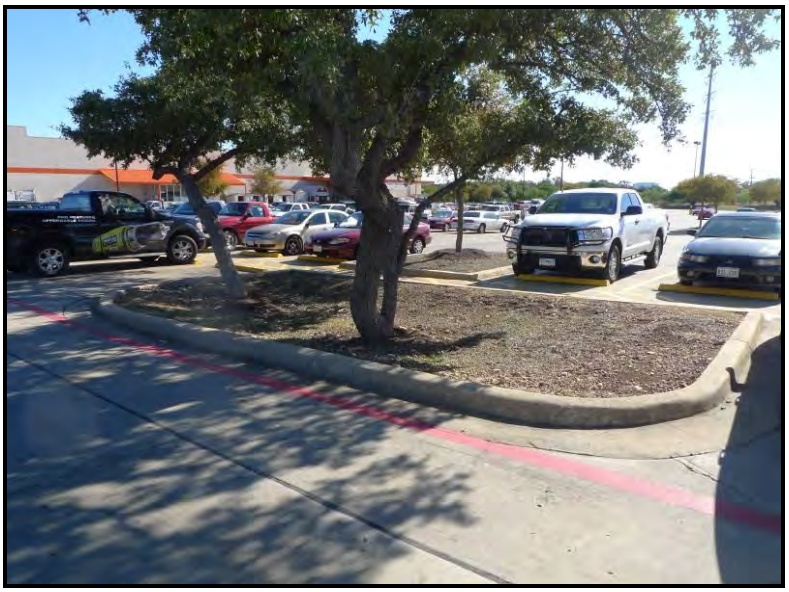

Figure 96. Overview of feature 281-059.

281-060, solution cavity/enlarged bedding plane This is an enlarged bedding plane opening in a road cut on the west side of US 281. It consists of three side by side openings within an area 2.25 m (7.4 ft) wide (Figure 97). They are 0.3 m (1 ft) tall and extend no more than 0.5 m (1.6 ft) into the road cut (Figure 98). This feature was not recommended for excavation (Table 1).

Figure 97. Overview of feature 281-060.

Figure 98. Interior of feature 281-060.

281-061, enlarged fracture This feature is an enlarged fracture developed along a trend of 90 degrees in a road cut on the west side of US 281. It is 0.4 m (1.3 ft) wide, 0.9 m (2.9 ft) tall, and extends into the road cut for 1.25 m (4.1 ft). No image is available for this feature. This feature was not recommended for excavation (Table 1).

281-062, cave This enlarged bedding plane in the road cut on the west side of US 281 had a 1.9 m wide and 0.75 m high entrance (Figure 99), and extended 2 m (6.6 ft)into the road cut. Excavation was conducted on 3 June 2010, when 3 m^3 of material was removed. These rocks were lightly cemented together with calcite, with voids between them. The excavation trended back underneath the roadway with an unstable ceiling, and excavation efforts ceased about 5 m into the feature (Figure 99). Post-excavation dimensions of the cave were 5.4 m long (17.7 ft) by 1.5 m (4.9 ft) wide and 3.4 m (11.1 ft) deep (Figure 101).

Biological surveys on this feature were conducted on 14, 21, and 29 June, and 12 September 2010. A complete list of fauna encountered in feature 281-062 is included in Table 13 and microclimate measurements are included in Table 14.

Table 13. Taxa encountered in feature 281-062.

Taxa	Order	Family	Species
Harvestmen	Opiliones	undetermined	
		Stygnopsidae	*Chinquipellobunus* sp. (**T**)
Spiders	Araneae	undetermined	
Millipedes	Spirostreptida	Cambalidae	*Cambala speobia* (**T**)
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
Centipedes	Scolopendromorpha	Scolopendridae	*Scolopendra* sp.*
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Mice	Rodentia*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 14. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-062. Pressure on 14 June 2010 obtained from weather underground-Encino Park, The Ridge.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
14 June	1025	Surface	24.8	29.5	1010	68.1
14 June	1105	In cave	25.2	25.8	1010	95.3
21 June	1510	Surface	25.5	34.5	977	48.7
21 June	1523	In cave	25.7	26.4	977	94.6
29 June	1016	Surface	26.2	30.1	976	73.6
29 June	1020	In cave	26	27	976	92.4

Figure 99. Overview of feature 281-062.

Figure 100. Interior of feature 281-062.

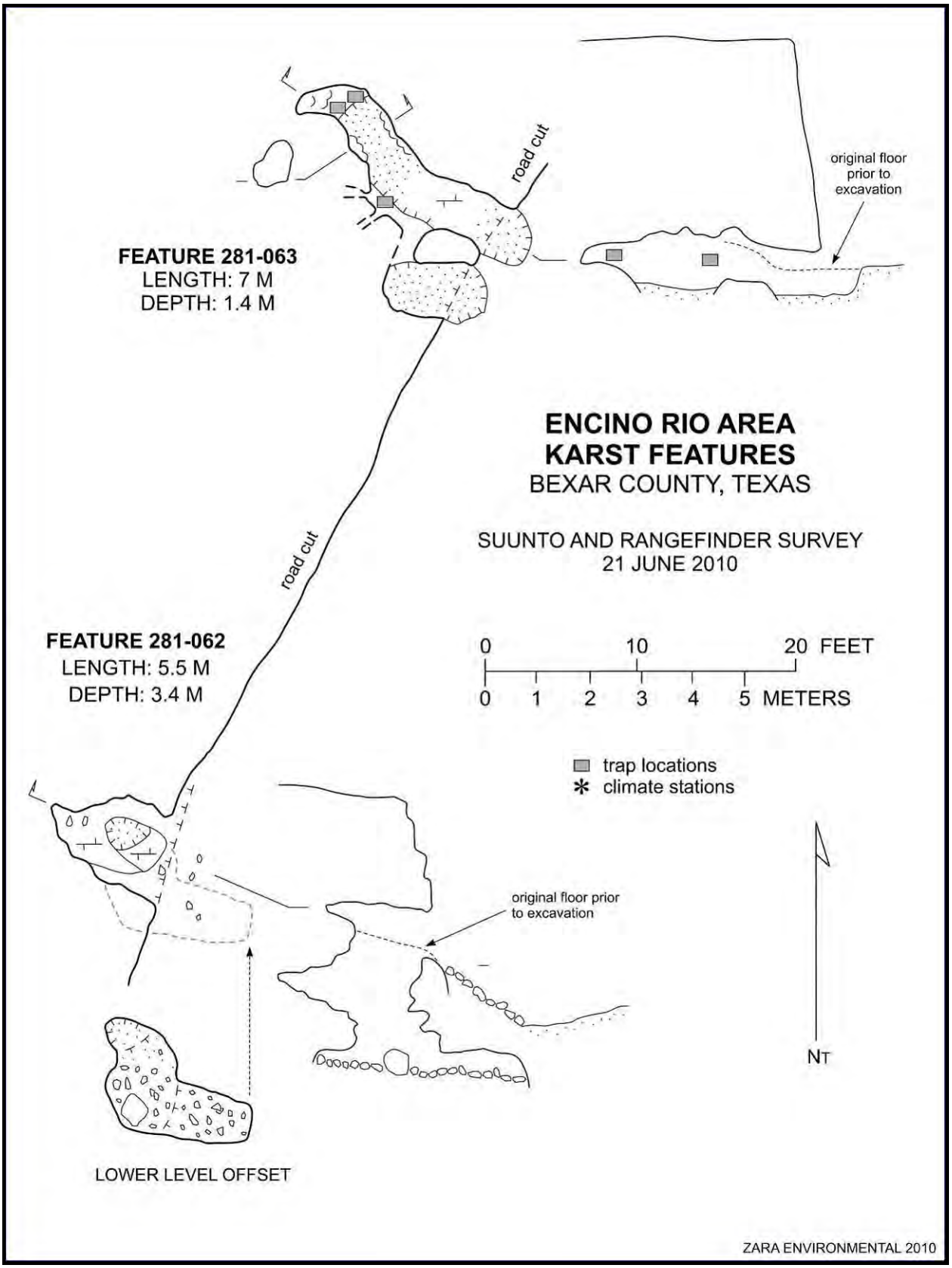

Figure 101. Map of features 281-062 and 281-063.

281-063, cave This feature is in the road cut on the west side of US 281, south of Encino Rio. It has two entrances at the base of the road cut that were initially 0.5 m (1.6 ft) wide (Figure 102).The northern entrance could be seen to extend 2 m into the road cut and continued on. It contained infill of leaf litter and modern soils. It was excavated on 3, 14, and 23 June 2010 (Figure 103). These excavations resulted in the removal of 3 m^3 (106 ft^3) of material from the feature. The resulting cave is 7 m (23 ft) long; with a small connection between the two entrances that is not passable (Figure 101). Each entrance is 1 m (3.3 ft) wide and both passages drop below the level of the roadway shoulder to a depth of 1.4 m (4.6 ft). The south entrance quickly rejoins the main passage in the north section. The cave ends in a flowstone wall. Biological surveys on this feature were conducted on 25 June, and 1, 9, 12, and 24 September 2010. A complete list of fauna encountered in 281-063 is included in Table 15 and microclimate measurements are included as Table 16.

Table 15. Taxa encountered in feature 281-063.

Taxa	Order	Family	Species
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi*
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. *(**T**)
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
		Porcellionidae	*Porcellio* sp.*
		Armadillidiidae	*Armadillidium vulgare**
Springtails	Collembola*		
Earwig-like Diplurans	Diplura	Campodeidae	
Flies and Gnats	Diptera*	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Cockroaches	Blattaria*	undetermined	
Mites	Acari*	undetermined	
Termites	Isoptera*	undetermined	
Earwigs	Dermaptera*	undetermined	
Frogs	Anura*	undetermined	
		Leptodactylidae	*Eleutherodactylus marnockii**
Geckos	Squamata*	undetermined	
Earthworms	Haplotaxida	undetermined	

*sight identification; (**T**) indicates troglobite

Table 16. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-063.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
25 June	1438	Surface	25.3	35.3	973	44.8
25 June	1445	In cave	25.4	26.0	973	95.3
1 Sept	-	-	-	-	-	-
9 Sept	1434	Surface	27.5	32.7	973	67.2
9 Sept	1443	In cave	27.5	27.7	973	98.5
12 Sept	1246	Surface	26.5	35.5	981	49.4
12 Sept	1218	In cave	28.5	31.0	981	82.9
24 Sept	1018	Surface	26.8	30.6	981	74.4
24 Sept	1025	In cave	28.0	29.0	981	92.7

Figure 102. Entrances to feature 281-063.


Figure 103. Interior of feature 281-063.

281-064, non karst closed depression This is a depression at the base of the road cut on the west side of US 281. When initially assessed it was 2 m (6.5 ft) in diameter and 0.3 m (1 ft) deep (Figure 104). It had fine infill of leaf litter and modern soils. It receives sheetwash from a drainage area of 600 m^2 (6,458 ft^2) from the bar ditch. It was excavated on 14 June 2010; 0.05 m^3 (1.8 ft^3) of material was removed with 2 person hours of labor. Post-excavation dimensions of the feature were 2 m (6.5 ft) in diameter and 1.25 m (4.1 ft) deep. Excavation reached a bedrock bottom with an apparent drain hole. However, this hole is actually a drill hole from the original road cut construction (Figure 105), not part of a karst feature.

Figure 104. Feature 281-064 prior to excavation.

Figure 105. Feature 281-064 after excavation, with drill hole visible.

281-065, enlarged fracture This is an enlarged fracture in the road cut on the west side of US 281 that had an opening 0.5 m (1.6 ft) wide and 1 m (3.3 ft) high (Figure 106). It dropped downward at least 0.5 m (1.6 ft). It was excavated on 17, 21, and 23 June 2010 for 17 person hours, removing 1.25 m^3 (44 ft^3) of hard rock with jackhammers. After to a depth of 1 m (3.3 ft), no voids could be seen extending from the feature (Figure 107). Post-excavation dimensions of the feature were 1 m (3.3 ft) in length by 1 m (3.3 ft) in width by 1 m (3.3 ft) in depth.

Figure 106. Feature 281-065 during excavation, showing solutionally-enlarged fracture.

Figure 107. Feature 281-065 after excavation.

281-066, enlarged fracture This feature is located in the road cut on the west side of US 281. It is an enlarged fracture/bedding plane trending at 90 degrees that is 0.5 m (1.6 ft) wide, 0.25 m (0.8 ft) tall (Figure 108), and it extends into the road cut for 1.25 m (4.1 ft) (Figure 109). This feature was not recommended for excavation (Table 1).

Figure 108. Overview of feature 281-066.

Figure 109. Interior of feature 281-066.

281-067, collapse sinkhole This feature appears to be a collapse sinkhole (Figure 110). It is 1 m (3.3 ft) in diameter and 0.3 m (1 ft) deep, with infill composed of black, modern soil, leaf litter, and rocks. It was recommended for excavation, but ROE for that purpose was denied.

Figure 110. Overview of feature 281-067.

281-068, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-069, solution cavity/enlarged bedding plane This enlarged bedding plane is located in the road cut on the east side of US 281 (Figure 111). It is 1.5 m (4.9 ft) wide, 0.5 m (1.6 ft) tall, and extends into the road cut for 1.5 m (4.9 ft). It has a coarse infill of rocks (Figure 112). This feature was not recommended for excavation (Table 1).

Figure 111. Overview of feature 281-069.

Figure 112. Interior of feature 281-069.

281-070, Stafford Cave This feature is located in the east road cut of US 281. It is an enlarged bedding plane that had an entrance 0.4 m (1.3 ft) in diameter (Figure 113), and it could be seen to extend 1.5 m (4.9 ft) into the road cut with a small opening continuing on. Slight airflow was detected. It was excavated on 16-17 June 2010. Fourteen person-hours of effort were utilized to remove rocks in order to make the crawlway passable (Figure 114). The cave can be entered for 9 m (29.5 ft) before it becomes too low to pass (Figure 115). The post-excavation width was 2 m (6.6 ft) and the depth was 1 m (3.3 ft). The cave was named for the brand of an article of clothing found in the entrance. A map of the cave and other nearby features is presented in Figure 116. Biological surveys on this feature were conducted on 18 and 25 June, and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-070 is included in Table 17 and microclimate measurements are included as Table 18. Stafford Cave is developed in the same bedding plane as numerous

other caves and karst features on both sides of US 281 just south of Marshall Road. This area has the greatest density of documented caves within the study area (Figure 117).

Table 17. Taxa encountered in feature 281-070.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus cunicularis**
			*Ceuthophilus secretus**
			Ceuthophilus sp. (nymph)*
Field Crickets	Orthoptera	Gryllidae (nymphs)*	
Harvestmen	Opiliones	Phalangodidae	*Texella ?tuberculata*[#] (**T**)
Springtails	Collembola*	Entomobryidae	*Pseudosinella violenta**
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Spiders	Araneae	Dictynidae	*Cicurina* (eyed: probably *varians*)
		Nesticidae	*Eidmannella* sp.*
	Araneae*	undetermined	(blind, immature)
Mites	Acari	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Millipedes	Spirostreptida*	undetermined	
Ants	Hymenoptera	Formicidae*	
Moths	Lepidoptera*	undetermined	
Gnats	Diptera*	undetermined	
Cockroaches	Blattaria*	undetermined	
Snails	Gastropoda*	undetermined	
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
	Anura*	undetermined	

*sight identification; (**T**) indicates troglobite; [#]See Appendix G for taxonomic verification

Table 18. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-070.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
25 June	1209	Surface	25	31.6	974	58.7
25 June	1212	In cave	24.5	25.3	974	93.7
25 June	1224	In cave	24.3	24.6	974	97.6
1 Sept	-	-	-	-	-	-
9 Sept	1017	Surface	25	28	975	78.5
9 Sept	1100	In cave	24	25	969	92.1
16 Sept	1351	Surface	26.5	30.5	970	73.2
16 Sept	1403	In cave	27.5	29.5	970	85.8
1 Oct	1157	In cave	24.2	24.4	976	98.4

Figure 113. Overview of feature 281-070.

Figure 114. Entrance to feature 281-070 after excavation.

Figure 115. Interior of feature 281-070 after excavation.

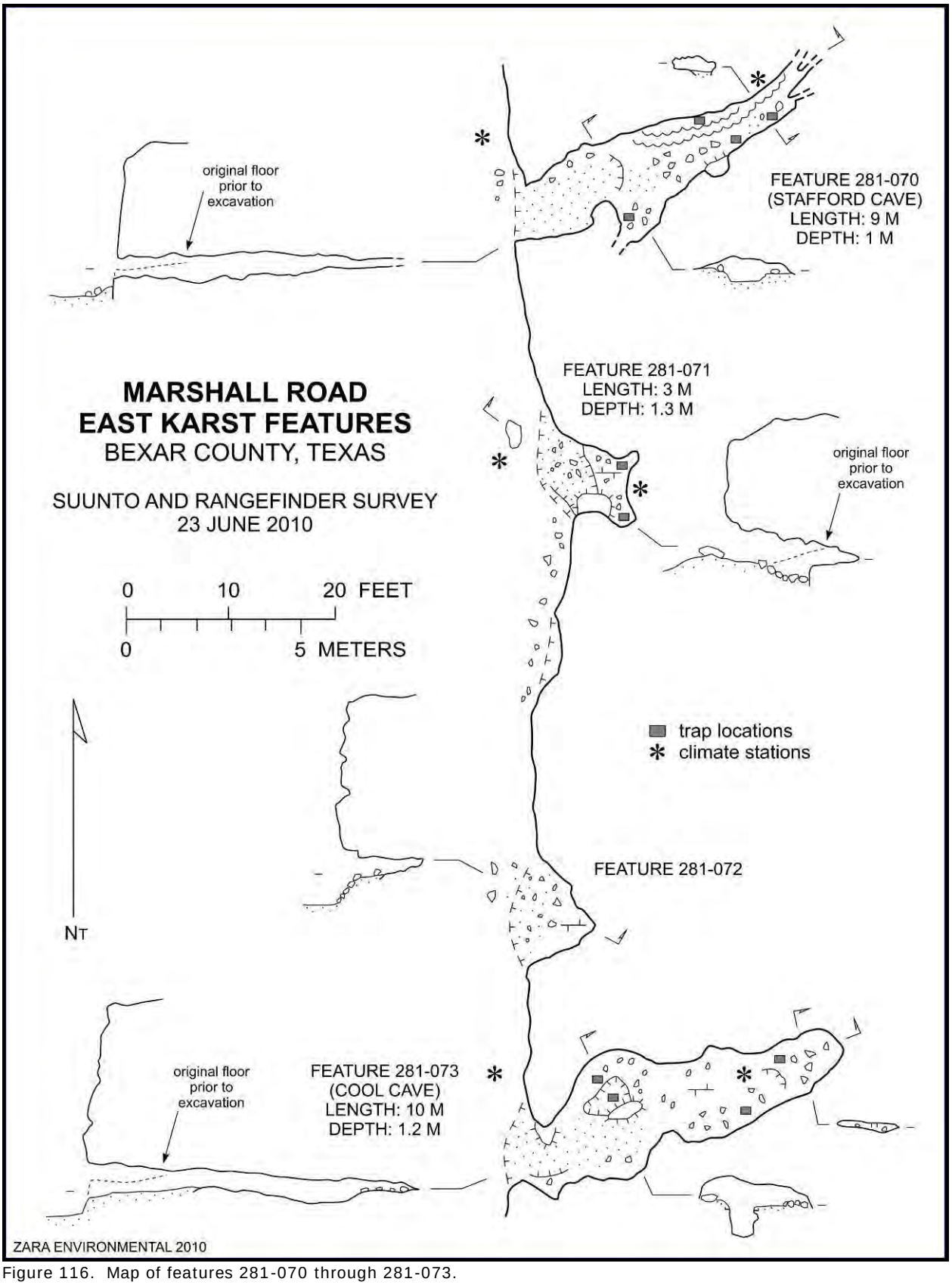

Figure 116. Map of features 281-070 through 281-073.

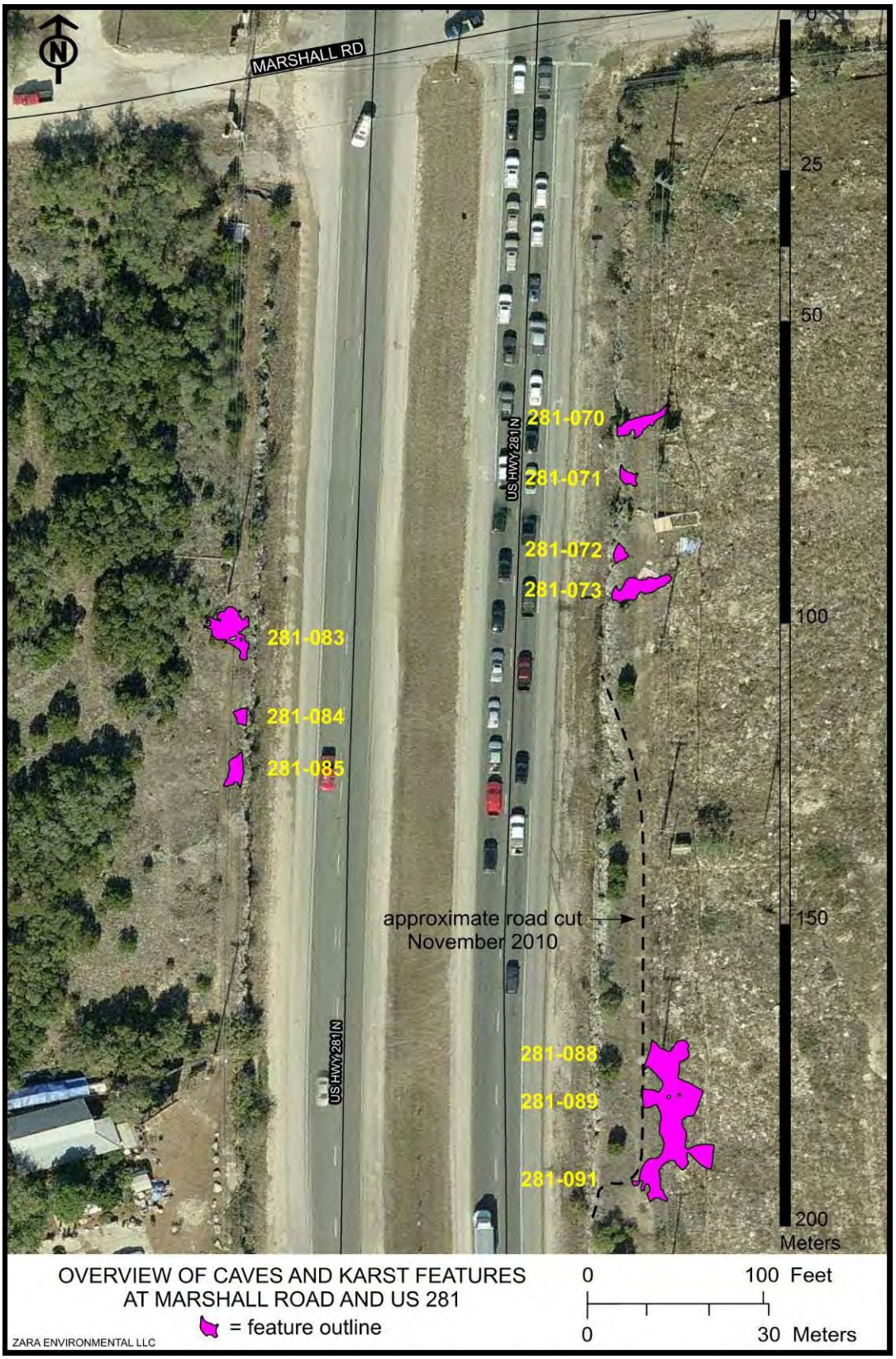

Figure 117. Overview of caves and karst features south of Marshall Road.

281-071, solution cavity/enlarged bedding plane This feature is located in the east road cut of US 281. It is an enlarged bedding plane with an entrance that is 2 m (6.6 ft) wide and 1 m (3.3 ft) high (Figure 118). It extended for 3 m (9.8 ft) into the road cut, with a small hole continuing on (Figure 119). Previous excavation has occurred here, as evidenced by a tailings pile just outside of the entrance. It was excavated on 16 June 2010. About 1 m^3 (35 ft^3) of rock was removed from the back of the feature, which was a bedding plane shelf with small openings continuing on (Figure 120). Further excavation effort would have required intense bedrock mining. Given that it was developed in the same bedding plane as the sample-able habitat in Stafford Cave and Cool Cave on either side of it, further excavation efforts were not deemed worthwhile. The post-excavation dimension were 3 m (9.8 ft) long by 2 m (6.6 ft) wide bay 1.3 m (4.3 ft) deep. One troglobite (*Brackenridgia* sp.) was encountered during excavation, so presence/absence surveys were performed.

Biological surveys on this feature were conducted on 18 and 25 June, and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-071 is included in Table 19, and microclimate measurements are included as Table 20.

Table 19. Taxa encountered in feature 281-071.

Taxa	Order	Family	Species
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
Spiders	Araneae	undetermined	(two species)
Antlion	Neuroptera	Myrmeleontidae	undetermined (nymph)
Gnats	Diptera*	undetermined	
True Bugs	Hemiptera*	undetermined	
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. *
Field Crickets	Orthoptera	Gryllidae*	(adult and nymph)
Springtails	Collembola*	undetermined	
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Barklice	Psocoptera*	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Gekkos	Squamata	Gekkonidae	*Hemidactylus turcicus**
Mice	Rodentia*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 20. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-071.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
25 June	1153	Surface	24.7	31.8	974	56.1
25 June	1204	In cave	25.2	28.0	974	79.9
1 Sept	-	-	-	-	-	-
9 Sept	1017	Surface	25.3	27.5	977	83.8
9 Sept	1021	In cave	21.7	25.5	977	71.8
16 Sept	1350	Surface	26.5	30.5	970	73.2
16 Sept	1442	In cave	24.5	29.2	970	68.2

Figure 118. Overview of feature 281-071.

Figure 119. Interior of feature 281-071 prior to excavation.

Figure 120. Interior of feature 281-071 after excavation.

281-072, solution cavity/enlarged bedding plane This is an enlarged bedding plane opening that is 2.5 m (8.2 ft) wide, 0.4 m (1.3 ft) tall, and extends 1.5 m (4.9 ft) into the road cut (Figure 121). Tiny mesocavernous voids extend off of it in the same bedding plane as surrounding caves and features (Figure 122). This feature was not recommended for excavation (Table 1).

Figure 121. Overview of feature 281-072.

Figure 122. Interior of feature 281-072.

281-073, Cool Cave This feature is developed in an enlarged bedding plane in the east road cut of US 281. When initially assessed, its entrance was 2 m (6.6 ft) wide and 0.5 m (1.6 ft) high (Figure 123). It extended at least 3 m (9.8 ft) into the road cut, with mesocavernous voids continuing on. It was excavated on 15-16 June 2010. Three m^3 (106 ft^3) of material was removed utilizing 20 person-hours of labor with hand and power tools (Figure 124). This resulted in enlargement of the entrance to 1 m (3.3 ft) in height, and enabled access to the full 10 m (32.8 ft) length of the cave (Figure 125). It was named for the cool temperature inside relative to the outside summer heat. The cave begins as a dirt-floored crawl, and widens out to 3.5 m (11.5 ft) across. At this point there is a shallow pit on the north side of the passage with a damp bedrock floor. The back portion of the cave gets very low. The post-excavation dimensions of this feature were 10 m (32.8 ft) long by 1 m (3.3 ft) wide by 1.2 m (3.9 ft) deep.

Biological surveys on this feature were conducted on 18 and 25 June, and 1, 9, and 16 September 2010 (Figure 126). A complete list of fauna encountered in 281-073 is included as Table 21, and microclimate measurements are included as Table 22.

Table 21. Taxa encountered in feature 281-073.

Taxa	Order	Family	Species
Spiders	Araneae	Dictynidae	*Cicurina varians* (female)
		Dictynidae	*Cicurina* sp. (eyed, immature)
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. *(**T**)
Springtails	Collembola	Entomobryidae	undetermined
			*Pseudosinella violenta** (**T**)
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi*
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (immature)

Taxa	Order	Family	Species
			Ceuthophilus sp. B
			*Ceuthophilus cunicularis**
Field Crickets	Orthoptera	Gryllidae*	undetermined
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
		Bufonidae	*Bufo nebulifer**
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Flies and Gnats	Diptera*	undetermined	
Cockroaches	Blattaria*	undetermined	

*sight identification

Table 22. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-073.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
25 June	1111	Surface	24.7	29.5	974	67.7
25 June	1115	In cave	23.7	24.8	974	91.3
25 June	1125	In cave	21.4	21.7	974	97.4
1 Sept	-	-	-	-	-	-
9 Sept	1040	Surface	25.5	27.3	977	86.6
9 Sept	1059	In cave	24.5	24.7	971	98.4
16 Sept	1415	Surface	26.5	30.5	970	73.2
16 Sept	1455	In cave	26	26.5	970	96.1

Figure 123. Entrance to Cool Cave prior to excavation.

Figure 124. Entrance to Cool Cave after excavation.


Figure 125. Interior of Cool Cave after excavation.

Figure 126. Glue trap retrieved from Cool Cave containing *Texoreddellia* subterranean silverfish and *Ceuthophilus cunicularis* cave crickets.

281-074, solution cavity/enlarged bedding plane This enlarged bedding plane opening is in the road cut on the east side of US 281 (Figure 127). It is 1 m (3.3 ft) wide, 0.3 m (1 ft) tall, and extends into the road cut for 1 m (3.3 ft) (Figure 128). This feature was not recommended for excavation (Table 1).


Figure 127. Overview of feature 281-074.

Figure 128. Interior of feature 281-074.

281-075, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane developed in the east road cut of US 281. When initially assessed it was 1 m (3.3 ft) wide, 0.4 m (1.3 ft) tall, and extended into the road cut for 1.5 m (4.9 ft) (Figure 129). It contained black, modern soil, rocks, and leaf litter. This feature receives channelized flow from the highway bar ditch. The troglophile meshweaver spider *Cicurina varians* was found in this feature. Excavation was conducted on 15 June 2010. Eight person hours of effort utilizing hand tools resulted in the removal of 1 m^3 (35 ft^3) of material. This resulted in the enlargement of the entrance to 1.5 m (4.9 ft) in diameter, and the floor was lowered to 1 m (3.3 ft) below the elevation of the bar ditch for a total depth of 2 m (6.6 ft). The floor was composed of clay that extended up the walls to meet the bedrock ceiling, with no voids visible (Figure 130).

Figure 129. Overview of feature 281-075.

Figure 130. Interior of feature 281-075 after excavation.

281-076, solution cavity/enlarged bedding plane This is an enlarged bedding plane in the east road cut of US 281. The entrance to the feature is 0.5 m (1.6 ft) wide and 0.3 m (1 ft) tall (Figure 131). It extends into the road cut for 1 m (3.3 ft). It contains no infill material (Figure 132). This feature was not recommended for excavation (Table 1).

Figure 131. Overview of feature 281-076.

Figure 132. Interior of feature 281-076.

281-077, solution cavity/enlarged fracture This feature is an enlarged fracture trending at 150 degrees. It is situated in the east road cut of US 281 (Figure 133). The entrance is 0.25 m (0.8 ft) wide, 0.25 m (0.8 ft) tall, and it extends into the road cut for 0.4 m (1.3 ft). It has minor amounts of rock infill, and flowstone covering some surfaces (Figure 134). Gastropod shells were observed in this feature. This feature was not recommended for excavation (Table 1).

Figure 133. Overview of feature 281-077.

Figure 134. Interior of feature 281-077.

281-078, solution cavity/animal burrow This feature is located in the east road cut of US 281. It is an enlarged bedding plane with an entrance that is 0.4 m (1.3 ft) wide and 0.2 m (0.7 ft) high. It extends at least 1.5 m (4.9 ft) into the road cut with a continuing void, and has slight airflow (Figure 135). It was excavated on 21 June 2010. Utilizing 6 person-hours of labor, 1 m^3 (35 ft^3) of material was removed; no continuing voids were seen (Figure 136). Post-excavation dimensions of the feature were 1.5 m (4.9 ft) long by 1 m (3.3 ft) wide by 0.5 m (1.6 ft) deep. The only fauna observed in this feature were two centipedes, one in the order Geophilomorpha and the other in the order Lithobiomorpha (family Lithobiidae). This feature appears to be an animal burrow.

Figure 135. Overview of feature 281-078.

Figure 136. Interior of feature 281-078 after excavation.

281-079, animal burrow This feature is located on private property on the east side of US 281. The entrance is 0.4 m (1.3 ft) wide, 0.3 m (1 ft) tall, and it extends in for at least 0.5 m (1.6 ft) (Figure 137). It appears to be epikarstic void that was enlarged by animal burrowing (Figure 138). This feature was not recommended for excavation (Table 1).

Figure 137. Overview of feature 281-079.


Figure 138. Interior of feature 281-079.

281-080, Power Pole Hole, cave This cave is located on the west side of US 281, to the south of Sonterra Boulevard. It is just inside the ROW, about 8 m (26.2 m) from the edge of pavement of the US 281 feeder road (Figure 139). This is a cave that was apparently intersected by power pole drilling installation operations sometime in the past. Although this feature was partially open when initially assessed, excavation was needed to remove fill material that had been dumped in, in order to access karst invertebrate habitat for sampling. A large quantity of recycled asphalt had been dumped into the cave in an apparent effort to plug the cave. Excavations were conducted on 20 May, 11, 12, 17, and 29 June, 19, 20, and 26 August, and 10 and 17 September 2010. A total of 8.16 m^3 (288 ft^3) of material was removed from the feature using 97.8 person-hours of effort.

The entrance to Power Pole Hole is 0.8 m (2.6 ft) in diameter and was covered with a limestone slab when initially encountered. The entrance appears to be a drilled hole created to anchor a power pole (Figure 140). The pole was installed in a new foundation 1 m (3.3 ft) to the southwest, presumably after the drillers realized that they had hit a void. Judging by fill-plugged in-feeders just below the surface, this cave may have had a natural entrance (or associated karst feature) in the ROW just to the east that was graded over during highway construction. When initially assessed, the cave consisted of a 3 m (9.8 ft) climb-down to a plugged floor. Fill material sloped down to the south end where two copper ground rods penetrated the ceiling from the power pole above (Figure 141). Excavation efforts concentrated on removing asphalt fill and opening up apparent passages extending off to the north and south. The northern crawlway went for 3 m (9.8 ft) to a terminus. The southern crawlway went down the slope past the ground rods, and then sloped upward in a low section that opened up into a spacious chamber (Figure 142). This chamber is about 7 m (23 ft) across and up to 4.5 m (14.8 ft) in height. Flowstone and stalactites cover parts of the ceiling, walls, and floor (Figure 143). Most of the floor consists of silt. Mesocavernous voids extend off of the western portion of the room at different points of the walls and ceiling. Post-excavation dimensions of this feature were 13 m (42.7 ft) long by 5 m (16.4 ft) wide) by 1 m (3.3 ft) deep.

This cave receives a considerable amount of moisture from various sources. Drainage is channeled into it by landscaping modifications related to an adjacent hotel. The hotel

filtration pond drains into it. Sprinklers installed to water the grass on the ROW also wet the cave.

Biological surveys on this feature were conducted on 16 and 24 September and 1 October 2010 (Figure 144). A complete list of fauna encountered in 281-080 is included as Table 23, and microclimate measurements are included as Table 24. A map of Power Pole Hole is presented in Figure 145.

Table 23. Taxa encountered in feature 281-080.

Taxa	Order	Family	Species
Scorpions	Scorpiones	Vaejovidae	*Pseudouroctonus reddelli*
Spiders	Araneae	undetermined	
		Dictynidae	*Cicurina varians* (immature)
		Dictynidae	*Cicurina* sp. (eyed)
		Dictynidae	*Cicurina bullis*[#]
Pseudoscorpions	Pseudoscorpionida	undetermined (eyeless)	
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Springtails	Collembola	Entomobryidae	undetermined
			*Pseudosinella violenta**
Harvestmen	Opiliones	Stygnopsidae	*Chinquipellobunus* sp. (**T**)
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
		Armadillidiidae	*Armadillidium vulgare**
Millipedes	Spirostreptida	Cambalidae	*Cambala speobia* (**T**)
	Polydesmida	Paradoxosomatidae	*Oxidus gracilis*
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			Ceuthophilus cunicularis
Field Crickets	Orthoptera	Gryllidae*	undetermined
Centipedes	Geophilomorpha	undetermined	
		Lithobiidae	undetermined
Earwig-like Diplurans	Diplura	Campodeidae	
Beetles	Coleoptera	undermined	(larva)
		Staphylinidae	undetermined
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Flies and Gnats	Diptera*	undetermined	
Earwigs	Dermaptera*	undetermined	
Moths	Lepidoptera*	undetermined	
Termites	Isoptera*	undetermined	
Snails	Gastropoda	undetermined	
	Stylommatophora	Helicodiscidae	*Helicodiscus* sp.
Gekkos	Squamata	Gekkonidae	*Hemidactylus turcicus**
Salamander	Caudata	Plethodonitdae	*Plethodon albagula**
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**

*sight identification; (**T**) indicates troglobite; [#] See Appendix G for taxonomic verification

Table 24. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-080 (Power Pole Hole).

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
16 Sept	0937	Surface	27	31	979	73.4
16 Sept	1004	In cave	27	30	979	79.3
16 Sept	1139	In cave	24	24.5	981	96
24 Sept	1051	Surface	30.5	24.9	981	63.5
24 Sept	1130	In cave	25.5	26.5	986	92.3
24 Sept	1125	In cave	24	26	986	84.8
1 Oct	1130	Surface	19.9	27.8	976	48.2
1 Oct	1138	In cave	25.6	26.6	976	92.3
1 Oct	1157	In cave	24.2	24.4	976	98.4

Figure 139. The entrance to Power Pole Hole had a rock partially covering it when initially assessed.

Figure 140. The circular drilling pattern can be seen in this image of the Power Pole Hole entrance.

Figure 141. A copper power pole ground rod pierces the ceiling at the entrance to the South Crawl in Power Pole Hole. A tar-like substance covers portions of the walls, apparently associated with the pole installation.

Figure 142. The South Crawl goes up a slope to emerge into the South Chamber in Power Pole Hole.


Figure 143. The South Chamber walls are partially covered in flowstone.

Figure 144. A biologist inspects the silt-covered floor of the South Chamber.

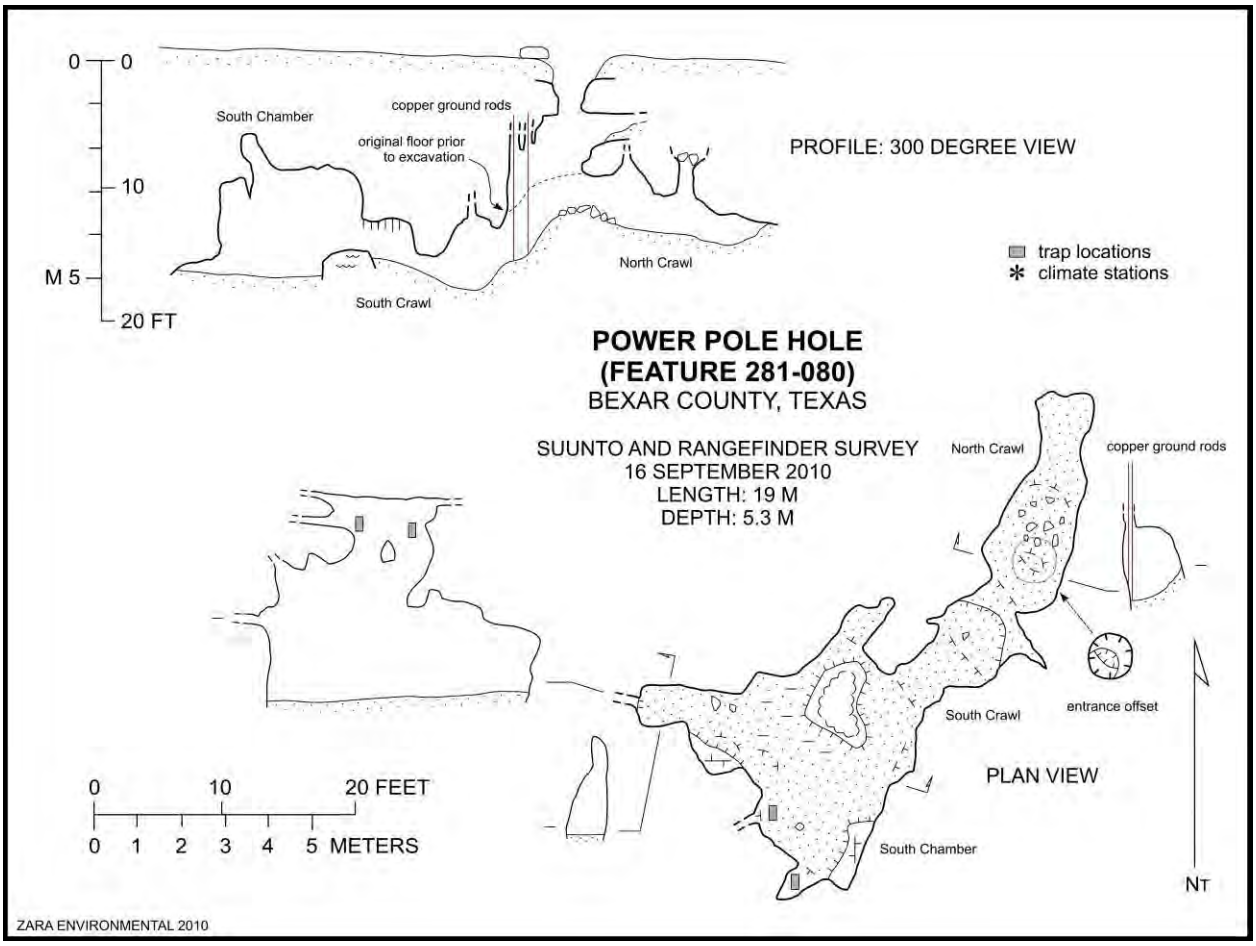

Figure 145. Map of Power Pole Hole.

281-081, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. It is an enlarged bedding plane with an entrance that is 1.5 m (4.9 ft) wide and 0.3 m (1 ft) high (Figure 146). It can be seen to extend into the road cut for at least 1.25 m (4.1 ft). This passage is initially 0.4 m (1.3 ft) wide, and splits into two branches which become smaller (Figure 147). The right hand branch contains some concrete in it of unknown origin. This concrete may have flowed out of this branch when some feature was plugged above it. Aside from the concrete, this feature has no infill material. Visible surfaces are covered with calcite. This feature was not recommended for excavation (Table 1).

Figure 146. Overview of feature 281-081.

Figure 147. Interior of feature 281-081. Concrete can be seen on the right rear side.

281-082, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. It is an enlarged bedding plane with an entrance that is 3 m (9.8 ft) wide and 0.5 m (1.6 ft) high (Figure 148). It extends into the road cut for 1 m (3.3 ft), and has no voids extending off of it. It contains no infill material and exhibits no evidence of moisture or speleothems (Figure 149). This feature was not recommended for excavation (Table 1).

Figure 148. Overview of feature 281-082.

Figure 149. Interior of feature 281-082.

281-083, Dripstone Cave This cave is located in the western road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane. Two entrances 3 m (9.8 ft) apart join up as a wide, low bedding plane void that was likely formed under phreatic[5] conditions (Figure 150). The cave is 13 m (42.7 ft) long by 5 m (16.4 ft) wide by 1 m (3.3 ft) deep. This cave is located at the very base of the road cut, and receives channelized recharge from the bar ditch. The entrance had been previously excavated. The walls and ceiling of this cave are mostly covered in calcite, which gave rise to the name Dripstone Cave (Figure 151). The floor is covered in loose, calcite-encrusted rocks. There is little organic debris, apart from some mammal scat. Several small voids extend off of the back of the cave (Figure 152).Biological surveys on this feature were conducted on 14, 21, and 29 June and 9 and 16 September 2010. A complete list of fauna encountered in 281-083 is included as Table 25.

Table 25. Taxa encountered in feature 281-083.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed)
		undetermined	(eyeless)
		Dictynidae	*Cicurina varians*
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp.* (**T**)
Springtails	Collembola	Entomobryidae	undetermined
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi*
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			*Ceuthophilus cunicularis**
Beetles	Coleoptera	Carabidae	undetermined
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**

[5] Phreatic: below the water table; indicating the feature was completely full of water and dissolution occurs in all directions.

Taxa	Order	Family	Species
Flatworm	Tricladida-Terricola	undetermined	
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
	Anura*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 26. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-083. On 14 June 2010, pressure was obtained from weatherunderground.com-Encino Park, The Ridge.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
14 June	1323	Surface	25.4	33.8	1010	50.6
14 June	1323	In cave	25.7	27.8	973	84.6
21 June	1005	Surface	24.5	29.3	973	67.6
21 June	-	In cave	24.5	25.6	973	91.4
29 June	0911	Surface	24.9	27.4	970	81.7
29 June	0920	In cave	24.9	25.5	970	95.3
9 Sept	1304	Surface	26.5	30.9	970	71
9 Sept	1327	In cave	26.8	27.0	970	98.5
16 Sept	1505	Surface	23.5	32	970	49.1
16 Sept	1510	In cave	27	28.5	969	89.1

Figure 150. Exterior of feature 281-083.

Figure 151. Interior of feature 281-083, with baited glue trap on left.

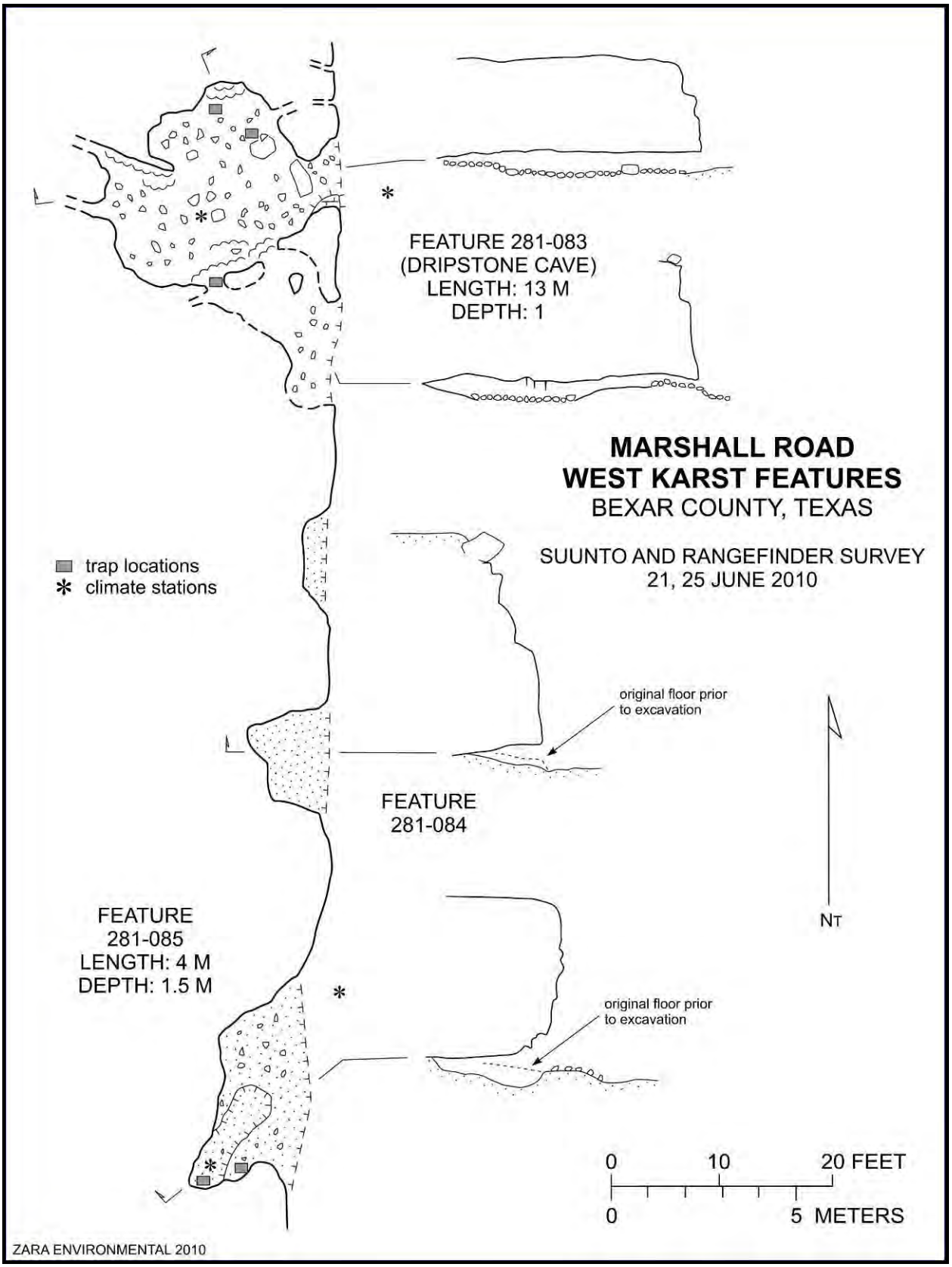

Figure 152. Map of features 281-083 through 281-085.

281-084, solution cavity/enlarged bedding plane This feature is located on the west side road cut of US 281, to the south of Marshall Road. It is formed in an enlarged bedding plane. When initially assessed the entrance was 1.3 m (4.3 ft) wide and 0.35 m (1.1 ft) high, and it extended over 1.5 m (4.9 ft) into the road cut (Figure 153). The passage made an 80 degree turn to the right beyond which it could not be examined, and thus was considered to be potentially humanly enterable. It was excavated on 18 June 2010. Using hand tools, 1.25 m^3 (44 ft^3) of material was removed with 9.5 person hours of effort. This enlarged the feature to 3 m (9.8 ft) in width 1.25 m (4.1 ft) in height, and it extended just over 2 m (6.6 ft) into the road cut. No continuing voids existed (Figure 154). Fauna encountered in feature 281-084 are included in Table 27.

Table 27. Taxa encountered in feature 281-084.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	
		Dictynidae	*Cicurina varians*
Subterranean Silverfish	Zygentoma	Nicoletiidae	
Beetles	Coleoptera	Carabidae	undetermined
Lizards	Squamata	Phrynosomatidae	*Sceloporus poinsettii**

*sight identification

Figure 153. Overview of feature 281-084 prior to excavation.

Figure 154. Interior of feature 281-084 after excavation.

281-085, solution cavity/enlarged bedding plane This feature is located in the western road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane at the base of the road cut, and it takes channelized drainage from the bar ditch (Figure 155). The entrance is 4 m (13.1 ft) wide and 2 m (6.6 ft) tall. When initially assessed it quickly became too low to enter, but extended at least 3 m (9.8 ft) into the road cut and was considered to be potentially humanly-enterable. Excavation was conducted on 18 June 2010 for 6 person hours, removing 0.75 m^3 (26.5 ft^3) of material from the feature. The floor was lowered, enabling the back of the feature to be examined. Post-excavation dimensions of the feature were 4 m (13.1 ft) in width and 2.5 m (8.2 ft) in height and extended 3 m (9.8 ft) into the road cut. No voids continued on (Figure 156), but the detection of troglobitic species during excavation prompted the initiation of presence/absence surveys. Biological surveys on this feature were conducted on 25 June and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-085 is included as Table 28.

Table 28. Taxa encountered in feature 281-085.

Taxa	Order	Family	Species
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)*
Spiders	Araneae	undetermined	(eyed)
		Dictynidae	*Cicurina* sp. (eyed)
Centipedes	Scolopendromorpha	Cryptopidae	*Theatops* sp.
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			Ceuthophilus cunicularis
			*Ceuthophilus secretus**
Flies and Gnats	Diptera*	undetermined	
Frogs	Anura*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 29. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-085.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
25 June	1330	Surface	25.4	32.2	973	58.1
25 June	1345	In cave	24.5	25.3	973	93.7
1 Sept	-	-	-	-	-	-
9 Sept	1304	Surface	26.5	30.9	970	71
9 Sept	1313	In cave	26.9	27.5	970	95.5
16 Sept	1438	Surface	26.5	30.5	970	73.2
16 Sept	1455	In cave	27	28	969	92.6

Figure 155. Overview of feature 281-085.


Figure 156. Interior of feature 281-085 after excavation.

281-086, solution cavity/enlarged bedding plane This feature is located in the western road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane. The entrance is 2 m (6.6 ft) wide and 0.45 m (1.5 ft) high (Figure 157). It extends 1 m (3.3 ft) into the road cut, at which point a small portal that is not humanly-enterable continues for an unknown distance (Figure 158). It is formed at the base of the road cut, taking channelized drainage from the bar ditch. Previous excavation has occurred here, as evidenced by a tailings pile just outside of the entrance. This feature was not recommended for additional excavation (Table 1).

Figure 157. Exterior of feature 281-086.

Figure 158. Interior of feature 281-086.

281-087, solution cavity/enlarged bedding plane This feature is located in the western side road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane. The entrance is 3 m (9.8 ft) wide and 1.5 m (4.9 ft) high (Figure 159). It extends 1.5 m (4.9 ft) into the road cut. There is no soil infill, and some of the surfaces are covered in

calcite. There are no mesocavernous voids extending from the feature (Figure 160). This feature was not recommended for excavation (Table 1).

Figure 159. Overview of feature 281-087.

Figure 160. Interior of feature 281-087.

281-088, Zombie Cave This feature was revealed by roadway widening construction in June 2010 (Figure 161). The entrance was 3 m (9.8 ft) wide, 0.5 m (1.6 ft) tall, and it could be seen to extend into the road cut for at least 4 m (13.1 ft). It was excavated on 23 and 26 August. Excavation removed rocks from the floor to enable access to the interior of the cave (Figure 162). Features 281-089 and 281-091, which are adjacent to the south, were

found to connect to it, giving this cave three entrances (Figure 163). All three entrances open into the same enlarged bedding plane, which it shares with other nearby caves in the road cuts south of Marshall Road. Noticeable airflow circulates through this cave, probably between these three entrances rather than from other sources. Maximum human penetration in Zombie Cave from the road cut to date is about 6 m (19.7 ft), but the enlarged bedding plane opening can be seen to continue on in a number of places which could be enlarged with more excavation effort. However, the excavation effort invested in this cave resulted in access to dark zone habitat and was deemed sufficient for the purposes of this study. At 38 m (124.7 ft), this cave is the longest one encountered in the course of this study. Post-excavation dimensions of the cave are 38 m (124.7 ft in length with an average width of 5 m (16.4 ft) and a depth of 1.5 m (4.9 ft). The cave was named for the fact that it suddenly appeared from out of the earth.

Biological surveys on this feature were conducted on 25 June and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-085 is included in Table 30.

Table 30. Taxa encountered in feature 281-088.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed)*
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			*Ceuthophilus cunicularis**
			*Ceuthophilus secretus**
Flies and Gnats	Diptera*	undetermined	
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
Mice	Rodentia*	undetermined	

*sight identification

Table 31. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-088 (Zombie Cave).

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
25 July	1020	Surface	23.8	28.0	974	70.6
25 July	1026	In cave	23.7	24.5	974	93.6
25 July	1032	In cave	24.2	24.7	974	96.8
1 Sept	-	-	-	-	-	-
9 Sept	1531	Surface	26.6	31.4	974	68.8
9 Sept	1340	In cave	26.5	27.8	974	90.3
9 Sept	1353	In cave	26.7	27.9	974	91.1
16 Sept	1525	Surface	-	-	-	-
16 Sept	1539	In cave	25	26.5	969	88.6

Figure 161. Entrance to feature 281-088 prior to excavation.

Figure 162. Interior of feature 281-088.

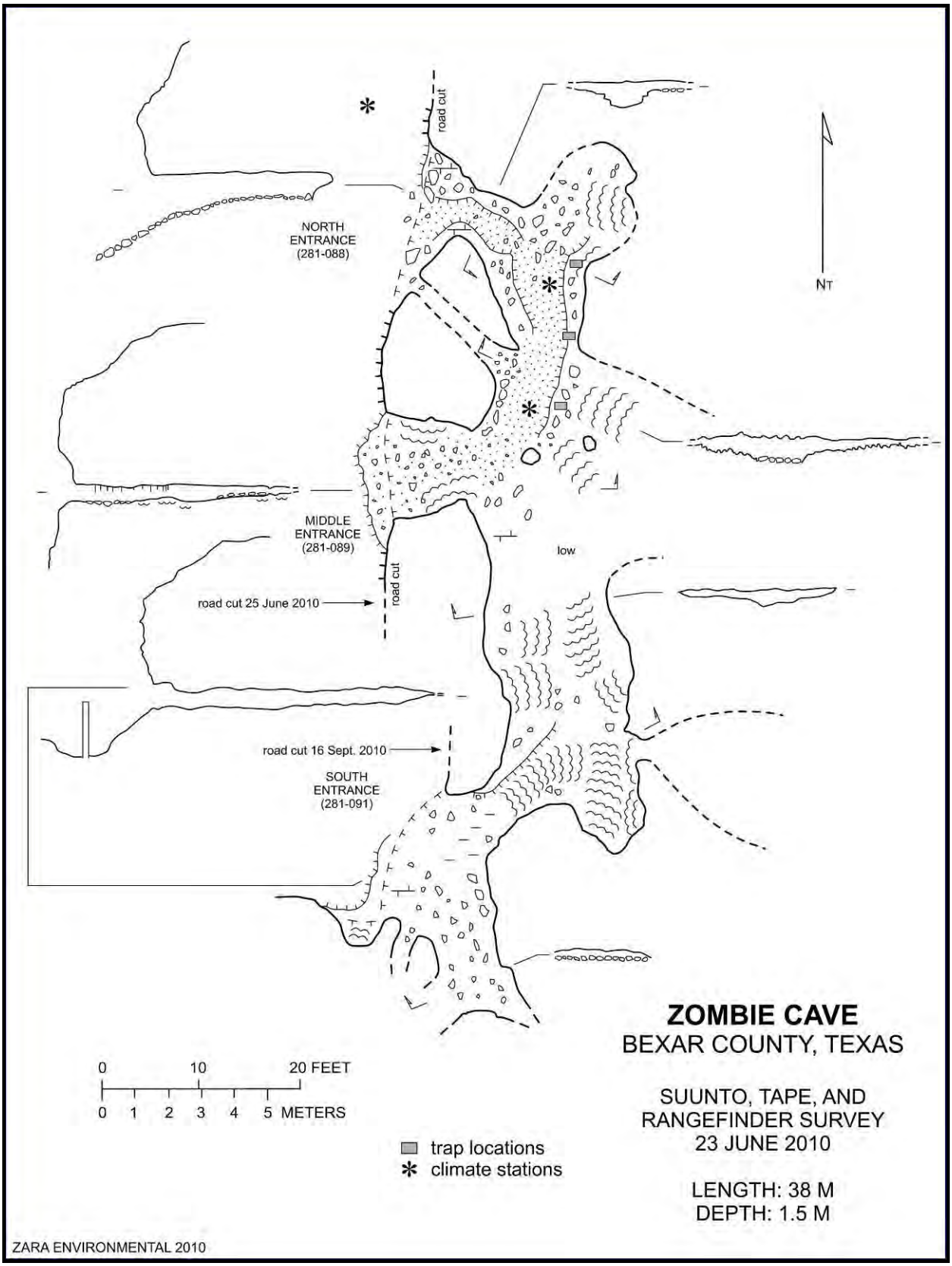

Figure 163. Map of Zombie Cave (features 281-088, 281-089, and 281-091).

281-089, Zombie Cave This karst feature is located in the road cut just south of Zombie Cave, and upon excavation and investigation was found to connect to it (Figure 164). See the description of 281-088 for more information.

Figure 164. Entrance to feature 281-089 prior to excavation.

281-090, solution cavity In August 2010 a construction team working on the installation of a traffic signal at the intersection of Evans Road and 281 encountered a karst feature while drilling a 1 m (3.3 ft) diameter foundation (Figure 165). Excavations were conducted on 25 and 26 August 2010 to remove drilling rubble in order to assess the void for karst invertebrate habitat (Figure 166). The drilled shaft was 3 m (9.8 ft) deep, with the void extending off of the north wall. The opening into the void extended from the floor of the shaft at -3 m (-9.8 ft) to a point 1.6 m (5.2 ft) above that. The total vertical extent of the void was 3 m (9.8 ft), with tiny voids extending off of the top and bottom of it. Post-excavation dimensions of the feature were 2 m (6.6 ft) long by 2.5 m (8.2 ft) wide and 3 m (9.8 ft) deep. Most of the surfaces within the void were encrusted with calcite, including the floor drain which effectively plugged it (Figure 167). Although the feature did not necessarily meet all of the guidelines presented in USFWS (2006) for warranting excavation or subsequent presence/absence surveys, a troglobitic species (*Texoreddellia sp.*) was encountered during excavation, prompting the initiation of presence/absence surveys, which were carried out on 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-090 is included in Table 32. A map is presented in Figure 168.

Table 32. Taxa encountered in feature 281-090.

Taxa	Order	Family	Species
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Springtails	Collembola	Entomobryidae	undetermined
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Field Crickets	Orthoptera	Gryllidae*	undetermined

*sight identification; (**T**) indicates troglobite

Table 33. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-090. The first biological survey performed on 8 April included collections and trap deployment, but in-cave temperature and humidity parameters were not measured.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
1 Sept	-	-	-	-	-	-
9 Sept	1138	Surface	26.5	30.5	971	73.2
9 Sept	1146	In cave	27.5	29.5	971	85.8
16 Sept	1343	Surface	23	34.4	977	37.7
16 Sept	1355	In cave	27.8	29.5	977	87.9

Figure 165. Overview of feature 281-090.

Figure 166. View down drilled shaft at feature 281-090 after excavation.

Figure 167. View of calcite-plugged drain in feature 281-090.

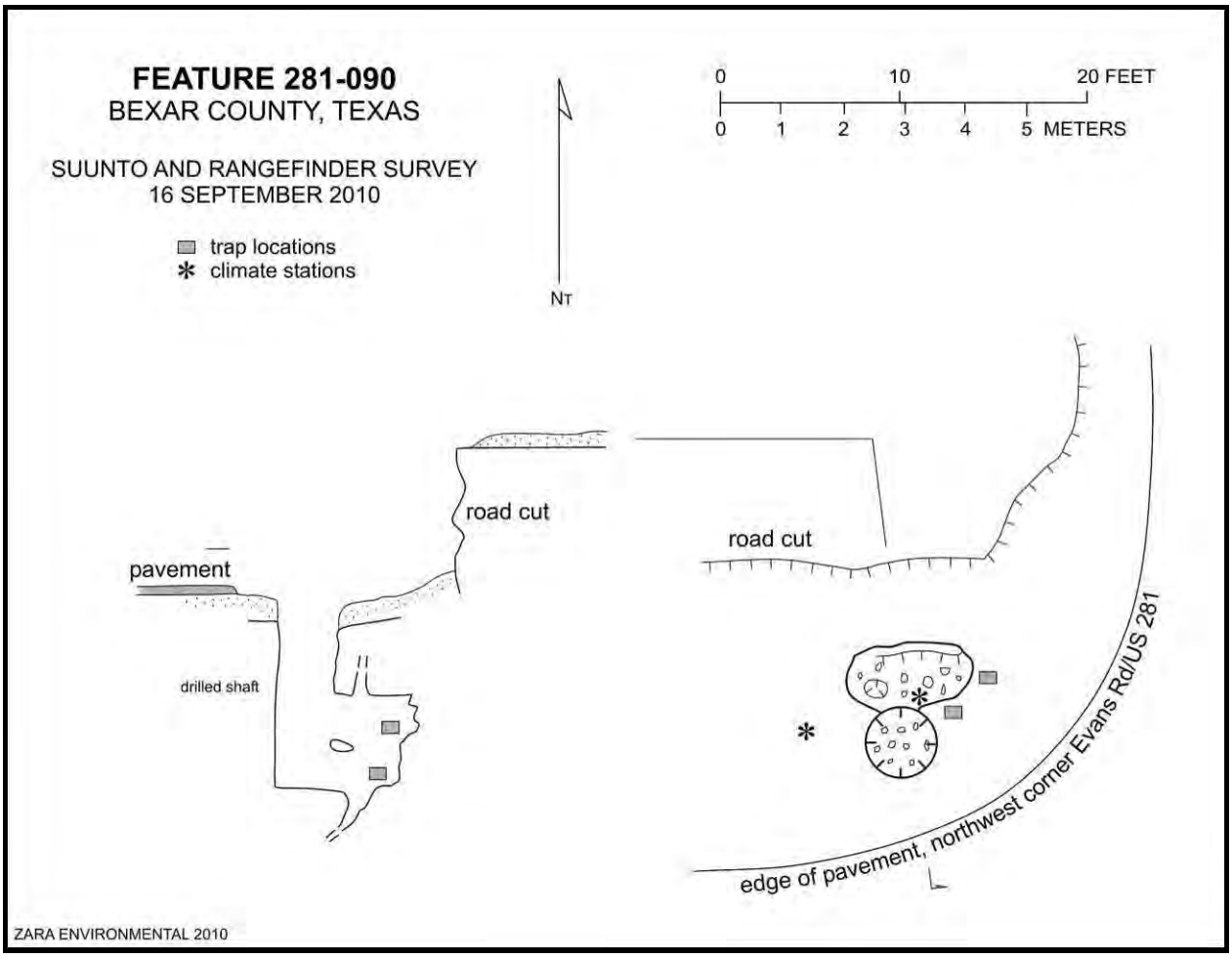

Figure 168. Map feature 281-090.

281-091, Zombie Cave This is another feature located in the road cut south of Zombie Cave (Figure 169). This feature was exposed during road widening activities in August 2010. Excavation conducted at that time resulted in its connection to Zombie Cave. See the description of 281-088 for more information.

Figure 169. Overview of feature 281-091 prior to excavation.

281-092, fault This feature is a geologic fault exposed in the road cut on the west side of US 281. It was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-093, fault This feature is a geologic fault exposed in the road cut on the west side of US 281. It was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-094, non-karst closed depression This is a shallow depression that is 4 m (13.1 ft) long, 1.5 m (4.9 ft) wide, and 0.3 m (1 ft) deep. It has a hard-packed clay floor, with no drains (Figure 170). It is likely the result of land clearing operations. This feature was not recommended for excavation (Table 1).

Figure 170. Overview of feature 281-094.

281-095, solution cavity This solution cavity is located in the eastern road cut of US 281. When initially assessed, it was 1 m (3.3 ft) wide, 1.3 m (4.3 ft) tall, and it extended into the road cut for 0.5 m (1.6 ft) (Figure 171). It contained some gravel infill that may be associated with construction excavation activities. The walls were partially covered with calcite. It is developed along a fracture trending at approximately 133 degrees. It was excavated on 1 October 2010. This effort removed 1 m^3 (35 ft^3) of material utilizing 6 person hours of labor. The feature was enlarged along the fracture to yield post-excavation dimensions of 1 m (3.3 ft) wide by 2 m (6.6 ft) tall, and it extended 1 m (3.3 ft) into the road cut (Figure 172). The fracture narrowed nearly to closure, with no airflow. A list of fauna encountered in feature 281-095 is included as Table 34.

Table 34. Taxa encountered in feature 281-095.

Taxa	Order	Family	Species
Spiders	Araneae	Dictynidae	*Cicurina* sp. (immature)
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**

*sight identification

Figure 171. Overview of feature 281-095.

Figure 172. Interior of feature 281-095 after excavation.

281-096, solution cavity/enlarged fracture This enlarged fracture is situated in the eastern road cut of US 281. It is 1 m (3.3 ft) wide, 1.2 m (3.9 ft) tall, and it extends into the road cut for 1.5 m (4.9 ft) (Figure 173). It contains some gravel infill that may be associated with construction excavation activities (Figure 174). This feature was not recommended for excavation (Table 1).

Figure 173. Overview of feature 281-096.


Figure 174. Interior of feature 281-096.

281-097, non-karst closed depression This feature is a depression measuring 10 by 25 m (32.8 by 82 ft), and is 4 m (13.1 ft) deep. It is old quarry pit that has bedrock walls on three sides. The east side is composed of fill that made this a closed depression. It was most likely originally open on the east side for material removal. It was recorded for purposes of the Geological Assessment, and is not a karst feature.

281-098, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane on a creek bank (Figure 175). The entrance is 0.75 m (2.5 ft) wide, 0.3 m (1 ft) tall, and it extends into the creek bank for 1.6 m (5.2 ft). A fracture is present in the feature that trends at approximately 150 degrees. It has a coarse infill of rocks (Figure 176). The roof of the feature is only about 0.5 m (4.9 ft) thick, and is in the process of being eroded away due to proximity to the creek, and this feature is a result of that process. This feature was not recommended for excavation (Table 1).

Figure 175. Overview of feature 281-098.

Figure 176. Interior of feature 281-098.

281-099, closed depression This is a probable non-karst closed depression that lies just across a fence from the ROW where ROE was denied. It is 1 m (3.3 ft) long, 0.8 m (2.6 ft) wide, and 0.2 m (0.7 ft) deep (Figure 177). It appeared to have infill of leaf litter and black, modern sediment. It may be surface disturbance associated with fence building. It was recommended for excavation, but ROE for that purpose was not obtained.

Figure 177. Overview of feature 281-099.

281-100, 281-101, water wells These features are wells that were recorded for purposes of the Geologic Assessment. They are not karst features.

281-102, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. The entrance to it is 0.3 m (1 ft) in diameter, and it extends into the road cut for 0.3 m (1 ft) (Figure 178). It has a coarse infill of loose rocks (Figure 179). This feature was not recommended for excavation (Table 1).

Figure 178. Overview of feature 281-102.

Figure 179. Interior of feature 281-102.

281-103, solution cavity This feature is located on private property on the west side of US 281 (Figure 180). The entrance is 0.25 m (0.8 ft) wide, 0.2 m (0.7 ft) long, and when initially assessed it dropped 0.4 m (1.3 ft) to a floor composed of organic debris and soil that was loose to a depth of loose. Preliminary excavation lowered the floor 0.1 m (0.15 ft), but more excavation would have required removal of some of the bedrock walls (Figure 181). This was recommended, but ROE for that purpose was denied.

Figure 180. Overview of feature 281-103.

Figure 181. Interior of feature 281-103.

281-104, solution cavity This consists of two solution cavities in the east US 281 road cut, one of which is associated with a fracture (Figure 182). The north cavity is 0.8 m (2.6 ft) wide, 1.2 m (3.9 ft) tall, and extends into the road cut for 0.2 m (0.7 ft). The south cavity is 0.4 m (1.3 ft) wide, 1.3 m (4.3 ft) tall, and extends into the road cut for 0.7 m (2.3 ft). These contain coarse infill of rocks that is likely a consequence of road cut excavation (Figure 183). This feature was not recommended for excavation (Table 1).

Figure 182. Overview of feature 281-104.

Figure 183. Interior of feature 281-104.

281-105, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. The entrance that is 3 m (9.8 ft) wide, 0.7 m (2.3 ft) tall, and it extends 1 m (3.3 ft) into the road cut (Figure 184). It contains no infill material (Figure 185). This feature was not recommended for excavation (Table 1).

Figure 184. Overview of feature 281-105.

Figure 185. Interior of feature 281-105.

281-106, enlarged fracture zone This is a zone of fractures in the streambed of West Elm Creek that was recorded for purposes of the Geologic Assessment. This feature was not recommended for excavation (Table 1).

281-107, solution cavity This appears to be a solution cavity encountered during down-cutting of bedrock grade in a private property construction area (Figure 186). It is 1.5 m (4.9 ft) long, 1.3 m (4.3 ft) wide, and is 0.25 m (0.8 ft) deep. It has an infill of rocks and fine white silt (powdered bedrock) that appears to have been graded into it (Figure 187). It was recommended for excavation, but ROE for excavation purposes was not obtained.

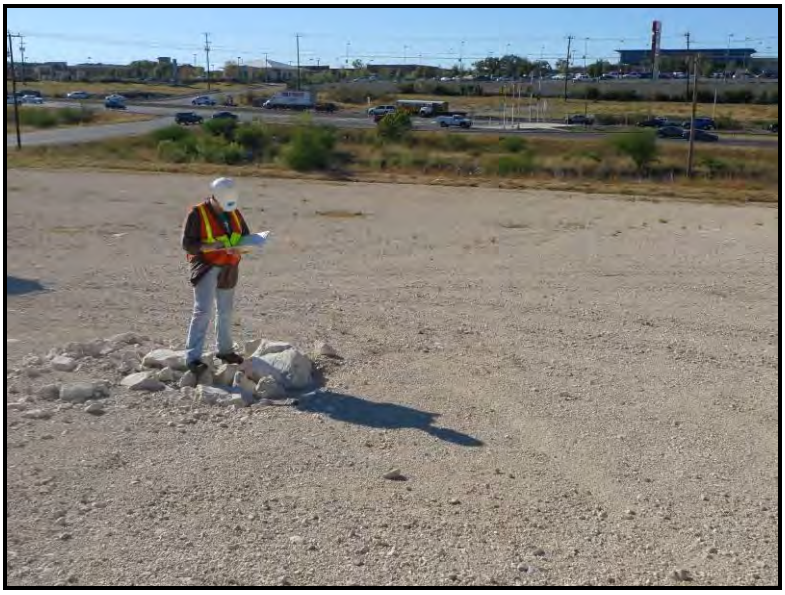

Figure 186. Overview of feature 281-107.

Figure 187. Feature 281-107 appears to have been back-filled with rocks.

281-108, non-karst closed depression This feature is located on the east US 281 ROW in an area that was partially cleared of trees in the past. It is 0.8 m (2.6 ft) long, 0.6 m (2 ft) wide, and is 0.3 m (1 ft) deep (Figure 188). When initially assessed, it had an infill of fine, modern soil. It was excavated on 16 November 2010, which resulted in the removal of 5 cm (0.2 ft) of soil to reveal a bedrock floor. This feature is probably a result of tree removal.

Figure 188. Overview of feature 281-108.

281-109, solution cavity This feature is located on private property on the west side of US 281. It consists of two 10 by 20 cm (0.3 by 0.6 ft) holes that are 1 m (3.3 ft) apart, one of them open and one plugged (Figure 189). The eastern hole drops for 0.2 m (0.7 ft) to dirt fill. This feature was recommended for excavation. No determination could be made about this feature due to lack of ROE for excavation purposes. From appearances this may

be an animal burrow under a slab of rock that has been mostly filled with soil by site grading (Figure 190).

Figure 189. Overview of feature 281-109.

Figure 190. Interior of feature 281-109.

281-110, 281-111, 281-112, 281-113, 281-114, 281-115, 281-116, faults These features are mapped faults recorded for purposes of the Geological Assessment. They are not karst features.

Significant Previously Recorded Features

The following caves are listed in TSS records, but were on property where ROE was not obtained and/or have now been destroyed.

Feature 23 Cave This is a cave that was opened up by excavation, and reaches a depth of 5.6 m (15 ft), with a footprint 12 m (40 ft) across. Seventeen invertebrate species have

been recorded within this cave, at least four of which are troglobites. Three presence/absence surveys conducted in 2006 did not detect any endangered karst invertebrate species.

Voight Cave No. 1 This site has a location puts it under a shopping center roadway surrounded by retail establishments, so it is doubtful that an entrance to it still exists. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site.

Tiny Town Sink This cave consisted of a 10 m (33 ft) drop from a small entrance into a room 4 m (13 ft) in diameter. The cave entrance was covered during widening of US 281 in the early 1970's (Veni 1988). It is known to contain cave crickets (TSS 2010), a trogloxene species whose presence suggests the possibility for endangered karst invertebrate habitat. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site; however, a list of taxa known from this cave is included in Appendix A.

C Section Cave This cave is 9 m (30 ft) deep and ends in a mud fill. This cave is known to contain cave crickets (TSS 2010), a trogloxene species whose presence suggests the possibility for endangered karst invertebrate habitat. ROE was not obtained for the location listed in TSS records; that location appears in imagery to now be under a gravel parking lot. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site; however, a list of taxa known from this cave is included in Appendix A.

Significant Features Outside of Buffer

A desktop review of known caves and karst features outside of the 152 m (300 ft) buffer out to 304 m (1000 ft) from the ROW turned up 85 such features. Of these, the following three sites are notable.

Feature F-3 This feature is an enlarged fracture located 987 ft from the US 281 ROW. An open void with slight airflow was reported at this feature (SWCA 2004), suggesting the presence of a cave with potential for containing karst invertebrate habitat. No excavations or presence/absence surveys for karst invertebrate species are known to have been conducted at this site.

Pomeranian Pit This cave is located 302 m (993) ft from the US 281 ROW. It is a narrow pit that drops 9.3 m to a dirt and rubble plugged floor (Veni 1988). This cave is known to contain cave crickets (TSS 2010), a trogloxene species whose presence suggests the possibility for endangered karst invertebrate habitat. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site. The apparent lack of dark zone habitat preferred by *Rhadine exilis* indicates that excavation at this site would be desirable in order to assess the possible presence of that species.

Pick-up Sticks Cave This cave is located 194 m (638 ft) from the US 281 ROW. It has a pit entrance that drops 15 m to a highly decorated chamber. It is located in a drainage and takes a considerable amount of recharge. Eleven species have been recorded from this cave, at least one of which is a troglobite (*Texoreddellia* sp.), however; presence/absence surveys for karst invertebrate species are known to have been conducted at this cave. A list of taxa known from this cave is included in Appendix A.

Climate Analysis

Detailed results of the climate analysis for each surveyed feature are presented in Appendix H, abbreviated results are presented here for ease of reference.

The first recommended climate criterion, that surveys be conducted within a season recommended by USFWS (2006), was met for all surveys. The second recommended climate criterion, that the area is experiencing "average" weather[6] for the time of year, was also met.

The monthly high, low, and average temperature and precipitation levels for survey months in 2010 were compared with the 30 year average, high and low temperature and precipitation data obtained from NOAA; the specific data are presented in Appendix H. The average temperatures for 2010 survey months were similar to the 30 year average temperatures for those months, and well within the range of the historical high and low records (Figure 191A). The precipitation levels for the 2010 survey months were similar to but fluctuated slightly from the 30 year average, but were significantly lower than record precipitation levels for the same months, and fell well within the range of the historical high and low records (Figure 191B).

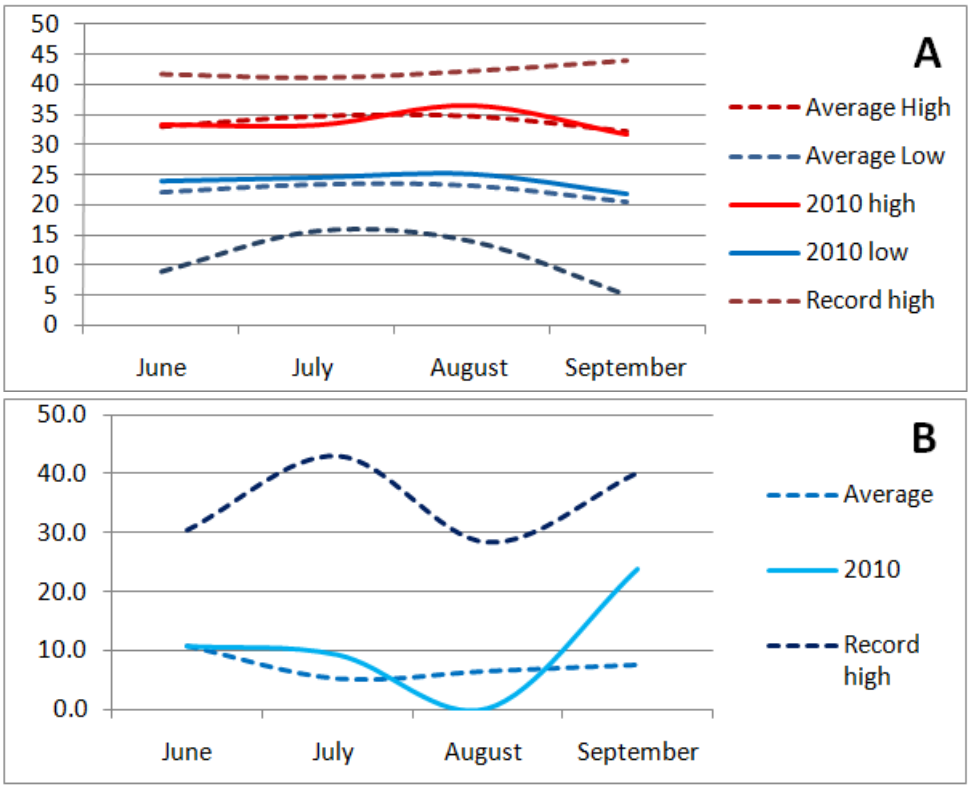

Figure 191. A) The 2010 monthly average temperatures (°C) for the survey months were near the 30 year average temperatures for the same months, and well within the historic record temperature ranges for the area. B) The 2010 monthly total precipitation (cm) for the survey months fluctuated slightly from the 30 year average precipitation for the same months, but fell well within the limits of the record levels of precipitation ranges for the area. Note that record low precipitation levels are not shown on the graph because they were 0 cm for all months indicated (NOAA 2002, 2010).

The third criterion, that surveys not be conducted within one week of exceeding the recommended surface temperature ranges, was met for each of the survey dates. The

[6] USFWS (2006) indicates that "weather" should mean temperature and precipitation.

fourth condition, lack of drought conditions, was met for all surveys. The fifth criterion, recent rainfall, was met for at least 1 survey in each feature[7]. The sixth criterion, absence of recent, extensive, local flooding, was met for each of the survey dates; however, surveys were repeated or postponed when they were scheduled to occur within two days of heavy rainfall.

[7] "Recent" is not quantified by USFWS (2006), and it is not unusual for the study area to lack rainfall for several months each year. The lack of rain within one week of some survey dates prompted the research team to perform additional surveys in some features in an effort to maximize detectability of karst invertebrates in the absence of the satisfaction of this criterion.

Conclusions and Recommendations

Surveys for listed karst invertebrate habitat were conducted within the existing ROW of US 281, and on private properties within 152 m (500 ft) of the existing and proposed ROW, where landowners granted access. Researchers recorded 116 features during these surveys, and identified 60 of them that had the potential to contain karst invertebrate habitat. Landowners that had granted access for initial karst feature surveys did not grant subsequent access to their property for excavation in the case of 15 features. The remaining 45 features that had potential to contain karst invertebrate habitat were excavated and re-evaluated for their habitat potential. These re-evaluations led to the identifications of 13 caves and karst features that were determined to contain potential habitat and were therefore surveyed for listed karst invertebrate species.

No federally-listed karst invertebrate species were detected during presence/absence surveys for this study and none are known to historically occur within the study area. The nearest recorded localities of federally listed karst species in the area are for *Rhadine exilis,* which is known from Ragin' Cajun Cave and Hairy Tooth Cave. These caves lie within CHU 12 (USFWS 2003), the edge of which is 180 m (591 ft) from the US 281 ROW.

One specimen of troglobitic harvestman was obtained from Stafford Cave (feature 281-070). This specimen has been tentatively identified as *Texella* near *tuberculata* (Appendix G). More specimens would be needed to make a definitive determination, however; *Texella* specimens are notoriously difficult to encounter in Bexar County caves. *Texella tuburculata* is currently confirmed from only two caves in western Bexar County, Surprise Sink and Logan's Cave (Ubick 2004, 106). Surprise Sink is located within Government Canyon State Natural Area, and Logan's Cave is on privately owned land within CHU 2 (USFWS 2003); therefore, both of these localities have a measure of protection already in place. Although this species is not federally listed, it is known from fewer sites than some of the listed karst species in Bexar County. An interesting aspect of this discovery is that the addition of the Stafford Cave site extends the species range 26 km (16 mi) to the east-northeast, leapfrogging over the extremely limited ranges of three other *Texella* species, *elliotti, hilgerensis, and whitei.*

The troglobitic spider *Cicurina bullis* was identified from Power Pole Hole (feature 281-080). This is the first occurrence of this species outside of Camp Bullis, where it is known from five caves. These caves are approximately 7 km (4 mi) to the northwest of Power Pole Hole (Cokendolpher 2004, 39-40). Power Pole Hole contained eight cave adapted species, eight of which are true troglobites, giving it the most diverse subterranean fauna assemblage of all the sites studied.

Both of these rare species caves contain *Ceuthophilus* cave crickets, which are important to the condition of the subterranean ecosystem. Cave crickets forage on the surface surrounding the cave at night, but they carry out many aspects of their life cycle in the cave, such as laying eggs and the deposition of fecal matter and corpses, all of which contribute energy to the system. Although cave crickets have been shown to forage up to 105 m (344 ft) from cave entrances (Taylor et al. 2005), the surface ecosystems surrounding these particular caves are degraded because they occur within the ROW of a major thoroughfare. Potential impacts to these caves may include further alteration of the natural plant and animal community surrounding the entrances and modifications to the current surface and subsurface drainage regimes. Because these caves contain no listed species, there are no federal regulations in place governing the management of the areas

surrounding them. However; because the species that occur in these caves are so rare, the potential impacts to the systems should be carefully considered when planning development activities within 105 m (344 ft) of their entrances.

As discussed in the Background Data portion of the Results Section, caves and karst features are known to exist on some of the unaccessed properties where landowners were unresponsive to or denied access. Conclusions about the status of listed karst invertebrate habitat in those areas cannot be made at this time. If access becomes available in the future, these features should be located and assessed for potential karst invertebrate habitat. Similarly, three springs identified as potential habitat for *Eurycea* salamanders should be sampled if future access is obtained.

It is possible that other potential karst features or caves may be revealed if any excavation occurs below the current grade or further into existing road cuts during anticipated improvements to US 281. If this occurs, work should immediately cease within 105 m (344 ft) of the feature, the feature should be covered, and a section 10(A)(1)(a) permitted karst biologist should inspect the site as soon as possible in order to evaluate potential species habitat.

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Note: In order to protect the rights and privacy of the landowners who participated in this study, appendices referenced in this document are not available for public distribution. These appendices contain private landowner contact information as well as specific spatial data for sensitive environmental features. This report and appendices were submitted to Vicki Crnich on March 9, 2011.

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